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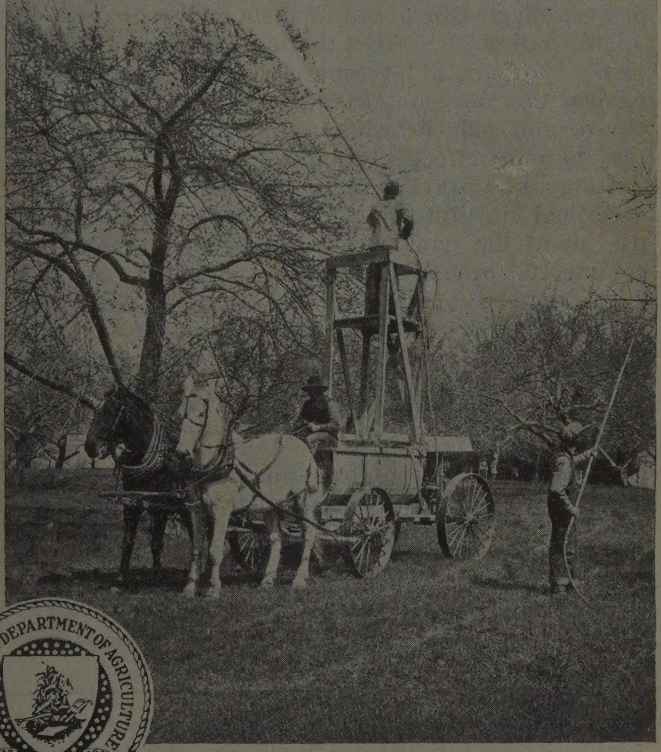
INSECTICIDES, EQUIPMENT, AND METHODS FOR CONTROLLING ORCHARD INSECT PESTS



1931

FOR THE SUCCESSFUL growing of fruit it is essential to keep down the numbers of insect pests that would otherwise render a large part of the crop unmarketable or even useless for any purpose.

A great many ways of combating fruit insects have been developed, based on the varied habits of the different insects. Some must be attacked through poisoning their food, others by actually touching them with the death-dealing spray or dust, and still others by preventing them from reaching their goal, or even digging them out of their retreats.

This bulletin describes the insecticides and treatments that are at present giving the best results against the more important insect pests of the orchard, and tells at what season these treatments may be most effectively applied. Various types of dusting and spraying apparatus, nozzles, etc., are described and illustrated. Both those intended for use about the home grounds and those for large commercial orchards are discussed.

The more common fruit pests and the nature of the damage they do are described, and for each the proper control measures are given, with schedules for spraying the apple, peach, cherry, plum, and grape.

465.

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INSECTICIDES, EQUIPMENT, AND METHODS FOR CONTROLLING ORCHARD INSECT PESTS

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NECESSITY OF CONTROLLING FRUIT INSECTS

INSECT CONTROL in orchards and vineyards is largely effected by spraying, and the needs of the fruit grower in the protection of his crops from the attack of insects and fungi [2] have been the predominating factors in the development of the present excellent lists of insecticides and a variety of spraying apparatus.

[1] Resigned Dec. 31, 1930.

[2] The statements in this bulletin as to the use of fungicides are made with the approval of the Bureau of Plant Industry, U. S. Department of Agriculture.

Although spraying is one of the more expensive of the several orchard operations, the value of the crop is so greatly increased thereby that it is a comparatively small investment, the expense amounting to only a fraction of the returns directly due to the practice. Orchard spraying is, in fact, an exceedingly cheap form of insurance.

It must not be inferred, however, that spraying operations are uniformly successful. While a considerable degree of skill in spraying has now been reached by a large proportion of fruit growers, there is still room for much improvement. Of all orchard work, spraying is most likely to be slighted or even neglected, and fruit growers need to have a more intimate knowledge of spraying materials, spraying machinery, and especially the whys and wherefores of spraying.

The term "spraying," unfortunately, has come to have a general meaning, and it is apparent that some fruit growers do not yet understand that the kind of spray and the manner of application depend upon the character of insect or insects to be controlled. The up-to-date orchardist will know just what each spray application is intended to do and will realize the importance of spraying at the proper time and in the proper way. A better understanding on the part of fruit growers of the life and habits of the insect pests of their crops and of the nature of insecticides will add much to the efficiency of their work in fighting them.

There are several important insect pests, however, for which spraying does not give protection, and the control of these must not be overlooked by the orchardist. Of these the most serious are certain species of borers, which are best destroyed by systematic "worming," once or twice each year. The great desirability of keeping insects reduced by up-to-date orchard practice, as fertilization, thorough cultivation, and attention to pruning and other operations can not be emphasized too strongly and is well appreciated by our most progressive and successful growers.

HOW INSECTS FEED

A knowledge of the character of the mouth parts of insects is of importance to the fruit grower, for the type of mouth part determines the general character of sprays to be used. Broadly speaking, all insects secure their food in one of two ways: (1) by actually biting out and swallowing portions of the food material; or (2) by sucking out the juices from the interior portions of the plant. The few exceptions to this general statement are unimportant in the present connection.

Biting and sucking types of mouth parts are on two quite distinct plans. In the former there are two horny, opposable jaws, working sideways, and certain accessory appendages, with which particles of the leaf, bud, fruit, or other food substance are cut out and passed on as more or less solid particles to the food canal for digestion. This type is found in several orders of insects, as in caterpillars, or the larvae of moths and butterflies, adult beetles and their grubs, grasshoppers, crickets, sawfly larvae, etc. (Fig. 1.)

Biting insects in general may be destroyed with arsenicals or other stomach poisons. Some biting insects, such as borers and

certain root-infesting forms, do not feed in situations where they can be reached by poisons, and for these a different treatment is necessary.

FIGURE 1.—Examples of insects with biting mouth parts: *a*, Grasshopper; *b*, *e*, beetles; *c*, *d*, sawfly larvae; *f*, caterpillar. These insects feed by biting off and swallowing pieces of their food

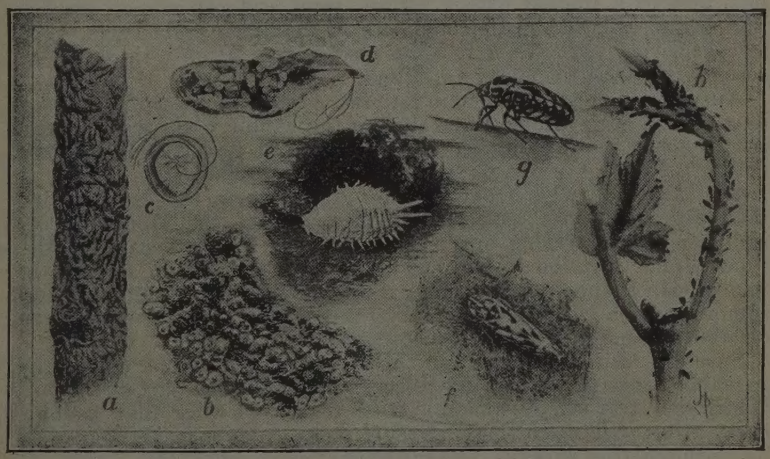

FIGURE 2.—Examples of insects with sucking mouth parts: *a*–*e*, Scale insects; *f*, leaf hopper; *g*, plant bug; *h*, aphids. These insects feed by sucking the juices from the plants

In most sucking insects of economic importance to the fruit grower, the mandibles and maxillae are drawn out into long setae, or bristles, which are inclosed in a greatly modified tubelike lower

lip, or beak, the four setae and beak constituting a sucking apparatus with which juices may be drawn up from plants. Plant lice, scale insects, leaf hoppers, the pear psylla, and the true bugs, very important enemies of the fruit grower, are sucking insects (fig. 2), and for their control the so-called contact sprays are used, which corrode the body or penetrate the breathing pores of the pests or otherwise effect their destruction by direct contact.

Biting and sucking insects often live in places which permit of their practical destruction by poisoning the air which they breathe, as with hydrocyanic acid gas or carbon disulphide. The fumigation of trees with hydrocyanic acid gas is extensively practiced in California for the destruction of scale insects infesting citrus trees, and to a less extent elsewhere. The use of this gas in the control of deciduous-fruit insects has been thoroughly investigated and on account of its cost has been discontinued in favor of spraying. Nursery stock, however, is now regularly fumigated by most nurserymen to guard against the possible dissemination of injurious insects (p. 29).

SPRAYING DORMANT TREES

The spraying of deciduous-fruit trees during winter and spring, when they are in a dormant condition, is directed largely against scale insects, especially the San Jose scale (*Aspidiotus perniciosus* Comst.) (p. 63). There are two principal advantages in spraying at this time: (1) The absence of foliage permits of more thorough applications; and (2) the sprays may be used at much greater strength than during the growing season. Contact sprays are employed, as lubricating-oil emulsions, lime-sulphur solution, miscible oils, and to a limited extent fish-oil soap and other soap washes. The prime essential is thoroughness in making applications, so as to cover every part of the tree, because in general only those insects actually hit with the spray are killed.

Applications may be made in late fall as soon as most of the leaves have fallen, at favorable times during the winter when the temperature is above the freezing point, or, preferably, in the spring shortly before the buds are due to swell. There is probably less danger to fruit buds and twigs from the use of sprays in the early spring than at other times, especially in the case of the lubricating-oil emulsions and miscible oils. Better results follow spraying with lime-sulphur solution in late spring than in late fall or during the winter, since this insures some spray on the trees during early summer, which is of value in killing any young scales, the offspring of adults which may have escaped destruction.

Spraying dormant trees for the San Jose and other scales and for other insect pests has come to be a very important part of orchard work, and it is usually possible so to time this work that a single application will reach most of the troubles that may be controlled by dormant-tree sprays. Other things being equal, the insecticide having the greatest range of usefulness should be employed. In most sections of the country lubricating-oil sprays have come into rather general use against the San Jose scale, and they are on the whole more effective than lime-sulphur against a number of other scale insects which may also infest the trees. Included among these are most other diaspine scales, as the cherry scale (*Aspidiotus forbesi*

Johnson), the walnut scale (*A. juglans-regiae* Comst.), the West Indian peach scale (*Diaspis pentagona* Targ.), the European fruit scale (*A. ostreaeformis* Curt.); and the lecanium scales, such as the terrapin scale (*Eulecanium nigrofasciatum* Perg.) and the brown apricot scale (*Lecanium corni* Bouché). The lubricating-oil emulsions are reasonably effective against the oyster-shell scale (*Lepidosaphes ulmi* L.) and the scurfy scale (*Chionaspis furfura* Fitch). In addition, the eggs of the European red mite (*Paratetranychus pilosus* C. and F.), of the fruit-tree leaf roller (*Cacoecia argyrospila* Walk.), and several stages of the pear psylla (*Psyllia pyricola* Först.), are more readily controllable by the use of oil sprays than by the use of lime-sulphur. Lime-sulphur, on the other hand, is quite effective against most of the scale insects listed above, is more effective than oil against the pear-leaf blister mite (*Eriophyes pyri* Pgst.), and with nicotine in the delayed dormant (p. 66) is the most completely effective spray against the apple and other aphids. Lime-sulphur has the further advantage of being an excellent fungicide, but it is somewhat disagreeable to handle.

SUMMER SPRAYING

By summer spraying is meant the application of spray materials during the period when the trees are in foliage. The work is directed principally against bud, leaf, and fruit eating insects; and for these arsenicals chiefly are used. Dilute contact insecticides also are employed in the control of certain sucking insects, as aphids, red bugs, leaf hoppers, etc.

The arsenical in most general use is lead arsenate, although calcium arsenate is also used to some extent. The foliage of stone fruits, as cherry, plum, and peach, is on the whole quite tender, and on these, arsenicals must be employed with caution. Lead arsenate is least likely to do harm, though more than two applications, especially to peach, may cause shot-holing and dropping of leaves, twig injury, and burning of the fruit.

Summer spraying is now almost universally employed in the commercial production of apples, peaches, and grapes, and spraying schedules have been arranged which are effective in the control of, or greatly reduce the losses caused by, the principal insect and fungous diseases of the fruit and foliage of these trees. (See pp. 71, 80, 83, 84, 89.)

GENERAL CLASSIFICATION OF INSECTICIDES

As already indicated, the important insecticides may be grouped principally into three series, as follows:

Insecticides for biting insects (stomach poisons).—Lead arsenate, calcium arsenate, and, to a much lesser extent, Paris green, are the principal stomach poisons used against insects that bite and chew their food. Hellebore is occasionally used on fruit which is about ready to be picked, especially on currants. Sodium arsenite, sodium arsenate, and white arsenic are used in poisoned baits, but are highly injurious to foliage, and consequently can not be used in foliage sprays. Several fluorine compounds, such as sodium fluosilicate, barium fluosilicate, potassium fluosilicate, potassium aluminum fluoride, and sodium aluminum fluoride (cryolite) are being

used in an experimental way, but as yet have not found a permanent place in orchard spraying.

Insecticides for sucking insects (contact sprays).—For insects that suck the plant juices contact sprays are used. The more important of these are lime-sulphur solution, lubricating-oil emulsions, miscible oils, kerosene and distillate emulsions, nicotine solutions, pyrethrum extracts, and derris extracts. Self-boiled lime-sulphur also has more or less value as a contact insecticide. Soap, caustic soda, caustic potash, and carbolic acid emulsion are occasionally used.

Fumigants.—Hydrocyanic acid gas, carbon disulphide, paradichlorobenzene, sulphur dioxide, etc., are effective against all classes of insects when it is feasible to use them.

STOMACH POISONS

ARSENICAL INSECTICIDES

LEAD ARSENATE

Lead arsenate is the best known and most extensively used stomach poison for insects, and it has a wider range of usefulness than has any other internal poison now available. It is safe for use on the foliage of most plants, possesses good adhesive qualities, and owing to its fineness remains in suspension well in water. Moreover, it can be safely combined with certain contact sprays, as nicotine, kerosene emulsion, etc., and with a number of fungicides, such as lime-sulphur solution, self-boiled lime-sulphur mixture, and Bordeaux mixture. It should not, however, be combined with sodium or potassium sulphides.

Lead arsenate is now available chiefly as a dry, fluffy powder, which has largely replaced the old paste form by reason of the convenience with which the dry material may be handled and stored, and the saving in transportation costs by the absence of water. Unless otherwise stated, the term "lead arsenate" in this bulletin refers to the dry form of acid lead arsenate. The paste form contains approximately 50 per cent of water, and twice as much should be used as of the dry form. Although nearly all the lead arsenate on the market to-day is the acid lead arsenate, a second form, known commercially as basic, tri-plumbic, or orthoarsenate, is less injurious to foliage. For this reason basic lead arsenate is used in spraying the sensitive foliage of the English walnut and is occasionally recommended for use on peach, plum, and other stone fruits. However, it is less rapid in its killing effect than is acid lead arsenate.

Lead arsenate is a standard product, and practically all brands contain at least 30 per cent of arsenic pentoxide (As_2O_5), and not more than three-fourths of 1 per cent of water-soluble arsenic.

DIRECTIONS FOR USE

Lead arsenate should be mixed into a thin paste with water before being added to the spray tank, although some growers sift it or work it through the screen as the spray tank is being filled. If paste lead arsenate is used, it should be thinned with a little water before it is added to the spray tank. For the control of most chewing insects which destroy deciduous-fruit crops, lead arsenate is used at a

strength of 1 pound in 50 gallons of water, although for some insects a greater strength is desirable.

When lead arsenate is used on peach foliage, 4 pounds of hydrated lime, or the milk of lime made by slaking 3 pounds of stone lime, should be added to each 50 gallons of water in order to reduce the danger of injury to the foliage. In many sections of the country, especially in the humid regions, this practice is also followed in spraying apples. When lead arsenate is used with a fungicide containing an excess of lime, the further addition of lime is unnecessary.

CALCIUM ARSENATE

Calcium arsenate, or arsenate of lime, is a compound somewhat similar to lead arsenate, in which the arsenic has been combined with lime instead of with lead. This material usually contains from 42 to 46 per cent of arsenic pentoxide. In addition to containing a higher percentage of arsenic than lead arsenate, calcium arsenate is somewhat cheaper on the pound basis. It is much more likely to injure foliage than is lead arsenate, and is unsafe for use on peach, cherry, plum, and other stone fruits. Even when used on resistant foliage, such as that of the apple, pear, and grape, injury has frequently been reported, and as a result this stomach poison is not in very general use against orchard insects. Calcium arsenate has also been found less effective than lead arsenate against the codling moth (*Carpocapsa pomonella* L.), although against many other insects the two appear to be about equally effective.

DIRECTIONS FOR USE

The same directions as have been given on page 6 for mixing lead arsenate for spraying should be followed in preparing calcium arsenate. For most chewing insects it is used at a strength of three-fourths of a pound in 50 gallons of spray. The risk of foliage injury may be considerably reduced by adding 4 pounds of hydrated lime or 3 pounds of stone lime (which should first be slaked). If Bordeaux mixture is being used with the insecticide, the addition of more lime is unnecessary.

PARIS GREEN

Paris green is an arsenical compound, the aceto-arsenite of copper, and was one of the first poisons used in the United States for the destruction of chewing insects. Paris green has been widely and extensively employed in the past, but in recent orchard spraying it has been largely superseded by lead arsenate.

Commercial Paris green should be finely ground, and as specified by the insecticide act of 1910 should contain not less than 50 per cent of arsenious oxide and not more than 3½ per cent of water-soluble arsenic. It is a heavy substance, and thorough agitation is therefore necessary in order to secure even distribution of the poison when applied as a liquid spray. It is not so adhesive as lead arsenate, though when used in Bordeaux mixture this objection loses much of its force.

Paris green should never be used on stone fruits, such as peaches, cherries, or plums. When used on apples, pears, grapes, or foliage having similar resistance to arsenical scorching, Paris green should

be combined with either Bordeaux mixture or milk of lime. It should not be mixed with lime-sulphur solutions. Paris green is ordinarily used in the proportion of 6 ounces in 50 gallons of water.

ZINC ARSENITE

Zinc arsenite was placed upon the market a few years ago in both paste and powder forms. The powdered zinc arsenite usually contains slightly over 40 per cent of arsenious oxide. In common with other arsenious compounds, zinc arsenite is an active poison, but it can not be used with safety except on very resistant plants. The danger of burning is reduced when this poison is combined with milk of lime or Bordeaux mixture. Zinc arsenite (powder) is generally used in the proportion of three-fourths pound to each 50 gallons.

LONDON PURPLE

London purple is a by-product in the manufacture of aniline dyes and contains a variable amount of arsenite of lime. It was formerly used as a substitute for Paris green, but owing to its variable composition, its high water-soluble arsenic content, and the resultant injury to the plant foliage, London purple is now seldom used in orchard spraying.

WHITE ARSENIC (ARSENIC TRIOXIDE)

White arsenic is an exceedingly active stomach poison and is generally employed in the manufacture of the arsenical poisons now in use. Owing to its causticity it can not be used as a spray material without severe burning of the foliage. White arsenic is used to some extent as a poison in insect baits.

ARSENICAL INSECT BAITS

Poisoned baits have proved very valuable for emergency purposes, especially to combat serious outbreaks of grasshoppers, cutworms, etc. These insects sometimes defoliate fruit trees, although grasses and grains usually suffer the most from them.

Insect baits made according to several formulas have been recommended, but those composed of poisoned bran sweetened with a sirup have been most extensively employed. These baits are easily made, reliable, cheap, and very effective. While they may vary somewhat in composition, a good standard bait for grasshoppers can be prepared as follows:

Wheat bran	pounds	100
Sodium arsenite solution (8-pound material)[3]	quart	1
Amyl acetate	ounces	3
Blackstrap cane molasses	gallons	2
Water	do	12

Mix thoroughly the water, molasses, amyl acetate, and sodium arsenite, and moisten the bran with this mixture. The bran may be mixed either by hand or machine, very much as cement is mixed.

[3] Sodium arsenite solution is on the market under a number of trade names, and is sold largely for use as a weed killer. The term "8-pound material" means that the solution contains the equivalent of 8 pounds of white arsenic per gallon. This form is more economical to use than the weaker solutions. In case the dry sodium arsenite powder is more readily obtainable, 4 pounds of it may be substituted for the quart of liquid sodium arsenite in the formula.

The resulting mash must be well mixed—not too wet, for it should crumble easily when scattered. The mash is scattered broadcast by hand at the rate of from 10 to 12 pounds per acre, wet weight, before the middle of the forenoon, since the hoppers eat most greedily between 8 and 11 a. m.

HELLEBORE

Hellebore is the powdered roots of the white hellebore plant (*Veratrum album*).[4] It contains alkaloids which are poisonous to insects, but which in the quantities properly used for insecticides do not seriously affect people. For this reason it may be used to protect fruit that is about to ripen, from injury by chewing insects. This material, however, is used only for small-scale operations, as it can not be profitably employed where many plants are to be treated.

Liquid application:			Dry application:	
Hellebore	ounce	1	Hellebore	ounce 1
Water	gallon	1	Flour (or air-slaked lime)	ounce 5 to 10

POWDERS FOR DUSTING

Insecticides and fungicides in dry or powdered form have long been used in insect and disease control, especially on low-growing plants. Interest has been manifested at different times in the use of dusts for the control of these troubles in orchards and vineyards, and extensive experiments have been made to determine the efficacy of such treatments. The dusts originally used in orchards were mostly composed of dry Bordeaux materials and Paris green. These dusts, on the whole, did not prove satisfactory substitutes for spraying and were little used, except under unusual orchard conditions. From time to time during the last 15 or 20 years a great deal of further work has been done with dusting, by experimental workers as well as by commercial fruit growers.

The material now used is finely powdered lead arsenate, usually with either a very finely divided sulphur or copper fungicide. The lead arsenate content ranges from 5 to 15 per cent, depending on the insect to be controlled and the plant to be treated. Occasionally, when the copper fungicides are used, calcium arsenate is substituted for the lead arsenate. In case no fungicide is needed, or a reduced quantity will accomplish the purpose intended, the bulk of the dust is increased by the addition of more or less of an inert filler, as hydrated lime, gypsum, or finely divided clay. Dusts containing nicotine, or calcium cyanide, to be discussed later, have also been used in orchards to a limited extent.

The application of insecticides and fungicides in the form of dusts, instead of diluted with water, has certain very definite advantages. Lighter machinery may be used, since the spray tank with its load of three-fourths of a ton or more of liquid is replaced by a light hopper and 100 to 200 pounds of dust; this is an important factor in rough, hilly orchards, or on soft ground. Dusting is especially useful in orchards which have an inadequate or an inconvenient water supply. The dusting method permits the covering of the

[4] Our native plant, *V. viride*, possesses about the same insecticidal properties as white hellebore and is now being used to some extent for insecticidal purposes.

planting much more rapidly than is possible with a sprayer, a decided advantage when large acreages must be treated within a limited period of time. The saving in labor costs, however, is offset by the greater cost for the dust materials, and the total costs of the two forms of application are approximately the same.

Under conditions of light or moderate infestation, dusting gives results nearly as good as those obtained by liquid spraying, and orchard dusting for insect control is most common in regions where the insect pests are not especially difficult to hold in check. When combating severe infestations of many insects, particularly of the codling moth or plum curculio, however, dusting has been found distinctly less effective than spraying. Many growers with extensive acreages utilize dusting as a supplement to spraying, to cover the ground quickly when there is not time for the slower operation of spraying, or for the rougher, more hilly portions of the orchards, where a heavy sprayer can not be conveniently used. Unfortunately, dusting with fungicides for various fruit diseases has not proven very effective, especially during years of serious infection. Where the usual practice of combining insecticides and fungicides is followed, liquid applications will be found more satisfactory than dusts. Dusts are to be used only on trees in foliage. For dormant tree treatment for the San Jose and other scales, sprays must be used.

QUANTITY OF DUST MATERIAL REQUIRED

Under average conditions about 2 pounds of the dust mixture will cover the same tree area as 10 gallons of liquid spray. The quantity of dust necessary for thorough work, however, will vary somewhat, depending upon air currents and whether these are variable or uniform in direction, the size and shape of the trees, the distance between the trees, and other factors.

APPLYING THE DUST

The dust material should be applied during very calm weather, as it is practically impossible to treat an orchard properly when the wind is strong. In recent years some growers have equipped their outfits with lights so as to apply the dusts during the night, when wind movement is at a minimum. Small trees may sometimes be well treated by dusting from one side only, but trees of moderate to large size must be dusted from two sides in order that they may be covered properly. As a general practice it is better to dust rapidly from two sides than to work slowly from one side. It is not necessary to apply the dust when the trees are wet with dew or rains, as the dust material will adhere to the dry foliage.

PREPARATION OF THE DUST

Dusts are readily made at home by weighing out the desired quantities of the respective ingredients and passing them through a mixing machine. Self-mixing dusting machines, however, are now available on the market. For small-scale work the mixing may be done by hand.

SPRAY RESIDUE

In recent years there has been an increasing belief that the indiscriminate use of poisonous materials on food products, such as

apples, pears, grapes, etc., constitutes a potential menace to health. Though most insect pests may be satisfactorily controlled without leaving excessive spray residues, there are some sections of the country in which adequate protection from insects can not be accomplished without leaving considerable quantities of lead arsenate on the fruit at harvest time. This problem has been especially acute in the control of the codling moth in arid regions, and at present the difficulty with residue is being met by washing the fruit in dilute hydrochloric acid. Effective washing machinery has been devised which cleans the fruit at a fairly low cost. Nearly all of the apples grown in the Northwest are now being washed before being placed on the market, and other sections of the country are gradually adopting the process.

CONTACT SPRAYS AND DUSTS

SULPHUR SPRAYS

LIME-SULPHUR

As stated elsewhere, lime-sulphur sprays are of value in the control of the San Jose and certain other scales, as well as of numerous other insects. When the lime-sulphur solution is properly diluted it is a very valuable fungicide for use on hardy trees in foliage and at the same time will destroy many of the newly hatched San Jose and other scale insects. As a summer spray it may be combined with lead arsenate and nicotine for the simultaneous control of many chewing and sucking insects and fungous diseases. Lime-sulphur solution should not be used with soap.

OLD FORMULA

Several years ago the home-cooked lime-sulphur wash was largely used for the control of the San Jose scale, but it has now been generally superseded by the commercial or homemade concentrates. Since inquiry is occasionally received as to its preparation, the old formula and method of making are given below:

Stone lime	pounds	20 or 2
Sulphur (commercial ground)	do	15 or 1½
Water to make	gallons	50 or 5

Heat in a cooking barrel or vessel about one-third of the total quantity of water required. When the water is hot add all the lime and at once add all the sulphur, which previously should have been made into a thick paste with water. After the lime has slaked about another third of the water, preferably hot, should be added, and the cooking should be continued for one hour, when the final dilution may be made, using either hot or cold water as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles. If cooked by live steam no stirring will be necessary. After the wash has been prepared it must be well strained as it is being run into the spray tank. It may be cooked in large kettles or preferably by steam in barrels or tanks. This wash should be applied promptly after preparation, since, as made by this formula, there is crystallization of the sulphur compounds and consequent hardening of the sediment upon cooling.

COMMERCIAL LIME-SULPHUR CONCENTRATES

For a number of years manufacturers have had on the market concentrated solutions of lime-sulphur which have only to be diluted with water for use. These standard commercial preparations, if used at proper strengths, have proved to be entirely satisfactory and are now used by most growers in preference to the homemade material. Where only a limited amount of spraying is to be done, as in the average home orchard, it will be especially convenient to use the commercial product. Lime-sulphur concentrates usually may be purchased from local seedsmen, implement dealers, or druggists, or from the manufacturers. They should have a density of about 33° on the Baumé scale and at this strength should be used as follows:

For dormant trees, 6¼ gallons to make 50 gallons of spray, or 5 pints to make 5 gallons of spray.

For hardy trees in foliage, 1½ gallons to make 50 gallons of spray, or 1¼ pints to make 5 gallons of spray. Some growers use a lower strength of lime-sulphur for the spraying of trees in foliage, diluting the concentrate 1¼ gallons to 50, or even as weak as 1 to 50.

For the dilution of lime-sulphur concentrate of a different strength from the standard 32° to 33° Baumé see the dilution table of page 13.

HOMEMADE LIME-SULPHUR CONCENTRATES

The question of the preparation at home of a lime-sulphur concentrate which will not crystallize upon cooling, thus duplicating the commercial product, has been investigated by the Bureau of Entomology as well as by numerous experiment station entomologists, notably by Stewart, Cordley, Parrott, and others. It has been demonstrated that it is practicable for orchardists to prepare concentrated stock solutions of lime-sulphur for immediate or later use, and since there is a saving in costs, some orchardists employ this plan. The necessary details for the preparation at home of lime-sulphur concentrates will be found in Farmers' Bulletin 1285,[5] Lime-Sulphur Concentrate, Preparation, Uses, and Designs for Plants, and will not be given here.

HANDLING AND STORAGE OF LIME-SULPHUR CONCENTRATES

In case the grower prepares his own lime-sulphur concentrate, it is very desirable in most cases to make up a supply during the winter or early spring, before spraying operations begin. It is quite feasible to do this, as the concentrated solution can be kept a year or more when properly stored. It should be placed in barrels or other tight receptacles and carefully stoppered so as to exclude the air as much as possible, as this wash deteriorates slowly when in contact with the air. The barrels or other containers should be filled completely, so that there will be little or no air space above the contents. If the container is not filled completely, the concentrate should be covered with a layer of heavy oil or paraffin. In the preparation of the lime-sulphur concentrate at home the disposition of the sludge is a question of practical importance. Commercial manufacturing plants are usually equipped with a filter press by means of which the wash as it comes from the cooking tank is filtered, freeing it from sludge and

[5] The bulletin may be obtained free on request to the U. S. Department of Agriculture.

sediment. There seems, however, to be no objection to storing the solution without removal of sludge, though the coarse sediment should be strained out before the material is used.

Lime-sulphur concentrate freezes at temperatures considerably below the freezing point of water; the stronger concentrates do not begin to freeze until the temperature drops nearly to zero. The strength of the solution may not be affected by freezing, but in order to avoid damage to the receptacles by expansion the concentrate should be stored where the temperatures are likely to remain well above zero.

DILUTION

It is very important to test with a hydrometer (fig. 3) the strength of all lime-sulphur solutions, to determine the proper amount of the concentrate that should be used for a given quantity of water. There are two kinds of these hydrometers, one with the Baumé scale and the other with the specific-gravity scale, and hydrometers may be purchased which have both scales on the same instrument. The Baumé-scale hydrometer is most commonly used. The clear solution at a temperature of about 60° F. should be used for the testing. If, however, the sludge has not been filtered out, the contents of the barrel or other container should be thoroughly stirred before the required amount for testing is taken out. The amount of dilution for concentrates for each degree Baumé from 20 to 36 and the corresponding specific-gravity reading can be determined from Table 1.

TABLE 1.—*Proper dilution of concentrated lime-sulphur solutions for various strengths of spray*

Degrees Baumé	Specific gravity	Quantity [1] of concentrated lime-sulphur [2] to make 50 gallons spray solution at—				
		Summer or foliage strength of—			Winter or dormant strength for—	
		1 to 50	1¼ to 50	1½ to 50	San Jose scale	Blister mite
		Gallons	*Gallons*	*Gallons*	*Gallons*	*Gallons*
36	1.330	¾	1	1¼	5½	4¾
35	1.318	1	1	1¼	5¾	5
34	1.306	1	1¼	1½	6	5
33	1.295	1	1¼	1½	6¼	5¼
32	1.283	1	1¼	1½	6½	5½
31	1.272	1	1¼	1½	6¾	5¾
30	1.261	1	1¼	1¾	7	6
29	1.250	1¼	1½	1¾	7¼	6¼
28	1.239	1¼	1½	1¾	7½	6½
27	1.229	1¼	1½	2	8	6¾
26	1.218	1¼	1½	2	8½	7¼
25	1.208	1¼	1¾	2	8¾	7½
24	1.198	1½	1¾	2¼	9¼	8
23	1.188	1½	2	2¼	9¾	8¼
22	1.179	1½	2	2¼	10¼	8¾
21	1.169	1¾	2	2½	11	9¼
20	1.160	1¾	2¼	2½	11½	9¾

[1] All quantities expressed in nearest quarter gallon. [2] 32° to 33° Baumé as standard strength.

In winter spraying for the San Jose scale and the pear-leaf blister mite about 5 per cent more of the solution should be used than the table of dilutions indicates, if the sludge has not been filtered out.

In summer spraying, however, no allowance for sludge is necessary, as a large percentage of this is composed of finely divided sulphur, which is of value.

LIME-SULPHUR SOLUTIONS FOR SUMMER SPRAYING OF POME FRUITS

Although used for the primary purpose of controlling fungous diseases, the summer strength lime-sulphur also assists a great deal in checking infestations of scale developing from individuals that may have escaped the dormant treatment, especially if the limbs, branches, and twigs are well coated, and will prevent to a large extent the infestation of fruit late in the season. Such infestation of fruit is very objectionable, especially on apples intended for export trade, as scale-infested fruit is excluded from entry by certain foreign governments and is discriminated against by buyers generally. The use of lime-sulphur as a summer spray does not, however, obviate the need of thorough dormant treatments for the San Jose scale where this insect is at all troublesome.

FIGURE 3.—Apparatus for determining specific gravity of lime-sulphur concentrate: *a*, Cylinder for liquid to be tested; *b*, specific-gravity spindle; *c*, Baumé spindle. The use of the hydrometer makes possible the dilution of the concentrate to exactly the proper strength

As already stated, the standard strength of lime-sulphur for summer spraying is 1½ gallons (of a concentrate registering 32° to 33° Baumé) in 50 gallons of spray. For the benefit of growers who prefer to use weaker solutions the proper dilutions for strengths of 1 to 50 and 1¼ to 50 are indicated in the third and fourth columns of Table 1.

DRY LIME-SULPHUR

In recent years a dry form of lime-sulphur has become available on the market. This is prepared by the evaporation of ordinary lime-sulphur concentrate, with the addition of a stabilizer to prevent the breaking down of the higher polysulphides, which are said to constitute the most active part of lime-sulphur. Water is

added to this to make a spray. The chief advantage of dry lime-sulphur is in the reduction of shipping costs and the increased ease and convenience with which the material may be handled without the added weight of water. Against the San Jose scale, however, dry lime-sulphur has proved less effective than the standard lime-sulphur concentrate [6] when the two are compared on the basis of an equal sulphur content and an equal degree of scale infestation.

SELF-BOILED LIME-SULPHUR MIXTURE FOR SUMMER SPRAYING OF STONE FRUITS

It may also be desirable to apply a summer spray to peach trees and other stone fruits for the San Jose and similar scale insects because of ineffective work during the dormant period of the trees. Under such circumstances the self-boiled lime-sulphur mixture should be used, since the foliage of most stone fruits will not stand the diluted lime-sulphur concentrate previously indicated for the apple, pear, etc. Self-boiled lime-sulphur is made up according to a formula quite different from any of the washes heretofore mentioned and has for a number of years been in general use as a fungicide for the control of peach scab and brown rot. Orchardists spraying for these troubles on peaches and other stone fruits may at the same time accomplish much in preventing the increase of the scale by thoroughly coating the limbs and branches of the trees while making the applications to the foliage and fruit.

The self-boiled lime-sulphur mixture may be made as follows:

Stone lime	pounds	8, or 2
Sulphur (commercial ground [7] or flowers)	do	8, or 2
Water to make	gallons	50, or 12½

The lime should be placed in a barrel and enough water poured on almost to cover it. As soon as the lime begins to slake, the sulphur should be added, after first running it through a sieve to break up the lumps. The mixture should be stirred constantly and more water added as needed to form at first a thick paste and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked, cold water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

The stage at which cold water should be poured on to stop the cooking varies with different grades of lime. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot 15 or 20 minutes after the slaking is completed, the sulphur gradually goes into solution combining with the lime to form sulphides, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of

[6] U. S. Department of Agriculture Bulletin 1371, Effectiveness Against the San Jose Scale of the Dry Substitutes for Liquid Lime-Sulphur.

[7] Commercial ground sulphur is the cheaper and is equally as satisfactory as the flowers of sulphur.

finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the finer particles of the mixture should be carefully worked through the strainer. Larger quantities can be prepared if desired, say enough for 200 gallons at a time, making the formula 32 pounds of lime and 32 pounds of sulphur to be slaked with a small quantity of water (8 or 10 gallons) and then diluted to 200 gallons. To make other quantitites of the mixture see the dilution table on page 61.

DRY-MIX SULPHUR-LIME

In recent years self-boiled lime-sulphur has been replaced to a considerable extent by a mixture of finely ground sulphur and lime to which a casein spreader has been added. The materials needed for 50 gallons of spray are as follows:

Finely ground sulphur	pounds	8
Hydrated lime	do	4
Calcium caseinate	pound	½

The ingredients should be thoroughly mixed; the mixture may then be stored in a dry place indefinitely. Lead arsenate may be used with this mixture, although for peach spraying the danger of arsenical injury to foliage and young wood necessitates the use of double the usual quantity of hydrated lime, 8 pounds in 50 gallons instead of 4.

Like self-boiled lime-sulphur, dry-mix sulphur-lime is used primarily as a fungicide, but it has more or less value in preventing the settling of young scales. When temperatures are very high, this material also is partly effective against the European red mite and certain other mites.

DUSTING WITH SULPHUR

Sulphur, in powdered form, is employed for the destruction of the red spider and other mites on plants in foliage. Commercial ground sulphur may be used and, if finely powdered, will be as effective as the more expensive flowers or sublimated sulphur. The sulphur in dry form may be used either pure or diluted with equal parts of a carrier such as hydrated lime, gypsum, flour, etc. When only a few plants or trees are to be treated, a small hand duster, fig. 25, p. 51) is sufficient, though larger apparatus (fig. 26, p. 52) will be needed for orchard work.

PETROLEUM-OIL SPRAYS

Petroleum oils have long been known to possess marked insecticidal properties, but their use in the control of orchard pests has been more or less restricted because of the danger of injury to the plants. In recent years much has been learned about oil sprays and their use, and the extent to which they are employed has been increasing very rapidly.

PETROLEUM-OIL SPRAYS FOR DORMANT USE

LUBRICATING-OIL EMULSIONS

When used in spraying orchard trees, oils are usually diluted with water in order to reduce the oil deposit left on the tree to the

quantity needed for effective control. The distribution of the oil in water is accomplished by a process known as emulsification, in which the oil is broken up into extremely fine droplets similar to the globules of butterfat in milk. A third substance, known as the emulsifier, holds the oil globules apart, and prevents their uniting in a separate layer of oil. In general, the oil is first emulsified with an emulsifying agent dissolved in a little water, forming a stock mixture containing from 50 to 90 per cent of oil. This stock emulsion is further diluted in the spray tank at the time of spraying.

Emulsions prepared from certain grades of lubricating oil have been in use in Florida for a number of years for the spraying of citrus trees. Early in 1922 it was found by the Bureau of Entomology that these emulsions, which may be prepared from very cheap lubricating oils, are also remarkably effective at low dilutions for the control of the San Jose scale on dormant deciduous trees. As a result, this type of spray has come into very general use in the dormant control of the San Jose scale and of a few other insect pests in many sections of the country.

The oils which have been found suitable for the dormant spraying of deciduous-fruit trees are the lighter lubricating oils, such as are used in slow-moving bearings, as well as a few of the oils ordinarily used for floor dressings. Such oils have sometimes been referred to as "red engine" oils, but this term is too inclusive to designate accurately the type of oil suitable for the control of insect pests. Certain technical specifications will describe more definitely the type of oil which has been found most satisfactory. The important properties appear to be viscosity [8] and volatility.[9]

The viscosity which an oil should possess to be suitable for dormant spraying seems to vary somewhat in different parts of the country. In the Ozark section of Arkansas, oils having a viscosity of about 200 seconds have been found to have the maximum effectiveness, and such oils are used by most of the growers in that section. Workers in the southeastern part of the United States recommend oils having a viscosity of 125 seconds or more. In the more northern fruit regions, oils having a viscosity of 90 to 100 seconds seem to give as good results as the heavier ones, possibly because the lower temperatures which normally prevail during the dormant season permit the oil to remain longer on the trees.

The volatility should be low; in other words, the oil should be one which will not evaporate too quickly.

Soap-oil emulsions

Probably the most widely known lubricating-oil emulsion is that prepared according to the formula developed by W. W. Yothers of the Bureau of Entomology for use in the control of citrus pests. This was first found effective in the control of the San Jose scale by A. J. Ackerman, also of the Bureau of Entomology.

[8] Viscosity is specified technically in seconds, the length of time it takes a given quantity of oil to pass through a given opening under standard conditions. (Tested by Saybolt universal viscosimeter.)

[9] Volatility indicates the percentage of the oil which evaporates under certain standard conditions in a specified time.

This formula utilizes soap as the emulsifier, and heat is necessary for the preparation of the emulsion. It is made up as follows:

Oil	gallon	1
Potash fish-oil soap	pound	1
Water	gallon	½

The soap ordinarily used is a liquid potash fish-oil soap containing 30 per cent or more of soap by weight. Potash soap is more satisfactory than soda soap, because it does not become hard on cooling. The water used should be soft if possible.

The ingredients are mixed together, the whole brought to a boil, and then, while still hot, pumped at least twice through a small opening, such as that in a spray gun or a very coarse disk nozzle. The emulsion should be pumped from one container into another, so that all of the material will pass through the pump. A bucket pump (fig. 17), vigorously used, will give a good emulsion, although for making large quantities a power-driven pump is of course desirable. The emulsions made with the larger pumps are usually more stable than those made with a bucket pump and will keep for longer periods of time, since the greater pressure breaks the oil up into finer droplets. Hot oil is very destructive to fiber or rubber pump packing, and if large quantities of emulsion are to be prepared, metal packing should be used. Various sources of heat have been successfully employed. Some manufacturers use a steam-jacketed copper kettle, while others use live steam introduced into the mixture through a coil in the bottom of the cooking vat.

This formula results in a stock containing approximately 66 per cent of oil by volume, some allowance for the manner of manufacture being necessary. If the stock is cooked in a shallow container over an open fire, excessive evaporation may unduly reduce the volume of water and thus increase the proportion of oil. The use of live steam causes a slight increase in the quantity of water present. The pumping sometimes incorporates more or less air into the mixture, but the emulsion usually shrinks to normal volume on standing and cooling.

Another emulsion, the resin-fish-oil-soap emulsion, is prepared without the use of heat, and is made up as follows: Lubricating oil, 9 gallons (about 65 pounds), resin potash fish-oil soap, 1 gallon (about 8 pounds).

Pour the soap into a suitable container, then add a quantity of oil not to exceed one-third of the volume of the soap. Stir rapidly until all the oil has disappeared into the soap, and the mixture has become somewhat stiff. Continue to add successively larger quantities of the oil (each additional quantity of oil never to exceed one-third of the total bulk of the mixture already made). Stir in thoroughly each addition of oil and do not add more until a stiff jellylike consistency is obtained. This procedure should be continued until the required quantity of oil has been emulsified. This emulsion may be made in a small way with a bucket and paddle, but for quantity production a power mixer is desirable. (Fig. 4.)

The stock emulsion made according to this formula contains approximately 90 per cent of oil by volume. It should be stored in air-tight containers. Any free oil found on the surface after the mixture has been standing may be stirred in again without

difficulty. The resin-fish-oil-soap emulsion is very resistant to the action of hard waters, which is a decided advantage in many localities.

Ordinary potash fish-oil soap may also be used in this formula when soft water is to be used in diluting the emulsion.

In dealing with any oil spray, the grower should keep in mind the fact that most mixtures of oil in water are temporary in nature and that the oil tends to separate into a distinct layer, which does not readily mix again with the water. This separation of oil, or breaking of the emulsion, renders the spray unsuitable for use, since the greater part of the liquid in the tank then contains insufficient oil for proper effectiveness, whereas the remainder of the mixture contains such a great proportion of oil that injury to the trees may result.

The complete separation of the oil just described should not be confused with "layering," or "creaming," which occurs with many diluted oil sprays. Layering is analogous to the rising of cream on milk, the cream in this case consisting of the globules of oil, accompanied by the emulsifier and any other solid or semisolid materials which may be present. While creaming often results in apparently distinct layers of materials, a moderate amount of stirring or agitation restores the entire mixture to its original uniform condition.

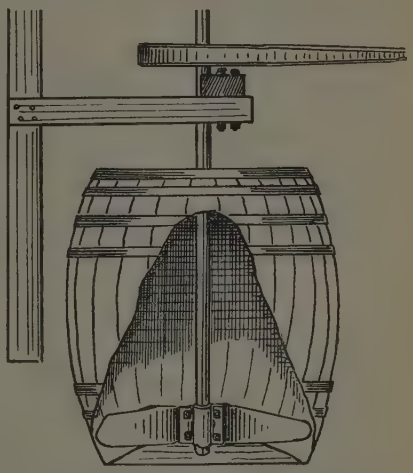

FIGURE 4.—Outfit suitable for preparing oil emulsions with resin fish-oil soap by the cold-stirred process

Use of soap-oil emulsions with hard waters.—When a soap-oil emulsion is diluted with hard water the soap is often rendered useless as an emulsifier; the oil is liberated and rises to the surface in the spray tank. If the water is only slightly hard, the use of a little additional soap in the preparation of the emulsion will often overcome the difficulty. The emulsions prepared with resin fish-oil soap are much more resistant to the action of hard water than those made according to the standard formula, and so may be used successfully in most limestone sections.

One means of overcoming difficulty with hard water, which has proved successful in many eastern and middle-western fruit districts, is by using a weak Bordeaux mixture (½–½–50) for diluting the emulsion. When the soap is eliminated by the action of the hard water, the Bordeaux acts as a substitute emulsifier and maintains the emulsion. The resulting mixture layers rather rapidly, however, and a moderate amount of agitation is needed to insure a uniform emulsion. The agitation provided by present-day sprayers is adequate for this purpose.

A residue of lime-sulphur in the spray tank will sometimes cause an oil emulsion to break down in a manner similar to that which occurs with hard water. All such foreign matter should be washed out of the spray tank before the use of a soap-oil emulsion is attempted.

Storage of soap-oil emulsions.—A well-made soap-oil stock emulsion is stable for a fairly long period, and no difficulty is likely to be experienced if the requirements for an entire dormant season are stored from fall until spring. A gradual separation takes place, however, and stock emulsions carried over from one year to the next are often in poor condition the second season.

Stock emulsions should be stored in clean containers. Old lime-sulphur barrels should not be used for storing soap-oil emulsions, since it is almost impossible to remove the lime-sulphur so completely that the emulsion will not be broken down by the action of the calcium salts present.

The boiled stock emulsion should be protected from temperatures much below freezing. Frozen emulsions sometimes break down, especially if they are moved about while still frozen. If allowed to thaw out gradually without being disturbed, however, they are seldom seriously damaged. The cold-stirred soap-oil emulsions do not freeze very readily and may be safely stored at temperatures nearly down to zero.

Boiled lubricating-oil emulsion which has been stored for long periods should be thoroughly stirred before any material is drawn off, since the excess water and soap present tend to settle to the bottom, forming a separate layer.

Cold-mixed emulsions

Certain other materials may be used as emulsifiers, and oil sprays prepared with these materials have some advantages not possessed by those in which soap is used, chiefly that of mixing readily with hard waters. Two of these emulsions were first suggested in this country by workers at the Missouri Agricultural Experiment Station and are sometimes referred to as "Missouri cold-mixed emulsions."

As the name implies, no heat is required in their preparation. One of these formulas, using a casein-lime spreader as an emulsifier, is as follows:

Oil	gallon	1
Calcium caseinate	ounces	2
Water	gallon	½

Work the calcium caseinate with some of the water into a thin paste free from lumps, add the remainder of the water and then the oil, and pump several times from one container into another through a small opening such as that in an ordinary spray gun. The preparation of satisfactory cold-mixed emulsions requires greater pressures than are needed in making the boiled soap-oil emulsion. An ordinary bucket pump is often inadequate for this purpose, and much better emulsions may be made with a power-driven pump.

The calcium caseinate should be fresh, since material which has been on hand for long periods is often unsuitable for use as an emulsifier. The stock emulsion prepared according to this formula should be used within a day or two from the time it is made up; if stored for longer periods the oil often separates, making it impos-

sible to obtain a uniform diluted emulsion. Some growers use a power sprayer for preparing cold-mixed emulsions, either mixing at one time the requirements for a short period or making only enough for each tank load as needed. In preparing large quantities the material is mixed in the spray tank, pumped into barrels or other containers, and then pumped back and forth until emulsification is complete. For this purpose an overhead suction hose is convenient. In making only enough for a tank load at a time, the quantity of material is usually small enough for a good emulsion to be made by merely pumping it through the spray nozzle back into itself for a few minutes before filling the tank with water.

The calcium caseinate-oil emulsions are usually unaffected by hard waters, although in New Mexico it has been found that waters containing large quantities of magnesium salts break down this type of emulsion.

A freshly made Bordeaux, consisting of 2 ounces of copper sulphate, 3 ounces of hydrated lime, and one-half gallon of water for each gallon of oil, may be similarly used for the preparation of a cold-mixed emulsion.

A number of proprietary cold-mixed emulsions have made their appearance on the market, and for the most part these products have given very satisfactory results. Most of them are in the form of a thick paste, containing from 75 to 85 per cent of oil. They should be used at the concentrations recommended on the label by the manufacturer.

Dilution of lubricating-oil emulsions

The dilutions recommended for lubricating-oil emulsions are usually expressed as percentages of oil, and refer to the content of actual oil, rather than to the proportion of stock used. The recommendations assume that the stock contains some standard proportion of oil—usually 66⅔ per cent. On this basis, to obtain 100 gallons of a 2 per cent diluted spray 3 gallons of stock will be required; 3 per cent of oil requires 4½ gallons; 4 per cent requires 6 gallons. If the stock material contains more or less oil than the 66⅔ per cent in the standard formula, the proper quantity of stock to use may be ascertained from Table 2.

TABLE 2.—*Dilutions of lubricating-oil stock emulsions of different oil content for obtaining various strengths of spray*

Oil content of stock material	Quantity [1] of stock needed to obtain 100 gallons of spray material having an oil content of—			
	1 per cent	2 per cent	3 per cent	4 per cent
	Gallons	*Gallons*	*Gallons*	*Gallons*
50 per cent	2	4	6	8
55 per cent	2	3¾	5½	7½
60 per cent	1¾	3½	5	6¾
65 per cent	1¾	3¼	4¾	6¼
66⅔ per cent	1½	3	4½	6
70 per cent	1½	3	4½	5¾
75 per cent	1½	2¾	4	5½
80 per cent	1¾	2½	3¾	5
85 per cent	1¾	2½	3¾	4¾
90 per cent	1¾	2¼	3½	4½

[1] Fractions are rounded off in each case to next higher quarter gallon.

KEROSENE EMULSION

Kerosene emulsion was one of the earliest of the petroleum-oil sprays and still is occasionally used. A stock emulsion containing 66 per cent of kerosene may be made by substituting kerosene for lubricating oil in the preparation of the formula on page 18. If the emulsion is cooked over an open fire the kerosene should not be added until the boiling soap solution has been removed from the fire, since kerosene is much more inflammable than the heavier lubricating oil. Kerosene emulsion is used at from 20 to 25 per cent of oil for dormant spraying and at about 10 per cent strength for foliage spraying. It has been largely replaced by the lubricating-oil emulsions and miscible oils for dormant work, and by the nicotine preparations for summer spraying.

DISTILLATE-OIL AND CRUDE-PETROLEUM EMULSIONS

Emulsions may also be prepared from distillate oils and from crude petroleum by following formulas very similar to those already indicated for lubricating oil. While formerly much used, such sprays have very largely given way to the lubricating-oil emulsions and the miscible oils.

MISCIBLE OILS

Miscible oils are also in very common use in dormant spraying. A stock miscible oil is clear and similar in appearance to ordinary lubricating oil. It has the emulsifier dissolved in it, but the oil is not broken up into droplets until water is added.

A number of reliable and effective proprietary miscible oils are available on the market. These oils differ greatly in composition, and no specific directions will be given here for their use, since recommendations as to their dilution and use will be found on the labels.

Miscible oils have certain advantages over the emulsions; they are very convenient to use, the mixing operations do not require such close supervision as is necessary with the emulsions, they cause little difficulty with hard waters, they may be stored indefinitely, and do not freeze readily.

The relative covering powers of the miscible oils and the lubricating-oil emulsions appear to be approximately equal, according to tests conducted by the Bureau of Entomology.

OIL SPRAYS FOR SUMMER USE

The oil sprays in common use for dormant spraying, when employed at effective strengths, are unsafe for use on trees in foliage; although in emergency cases certain emulsions of ordinary lubricating oil have been used on apple (but not on peach) with comparatively little injury. In recent years it has been found that highly refined oils of the type used for medicinal purposes, and often referred to as "white" or "crystal" oils, may be used during the growing season with less danger of injury. These summer oils are available chiefly in the form of cold-mixed emulsions of the paste type.

Under the pressure of the spray-residue problem, the white oils have been used quite extensively in an experimental way against the codling moth, especially in the Northwest. The results of these experiments indicate that the summer oils may have a place in the

apple-spray program, especially in combination with nicotine, for the control of the second and later broods of the codling moth. In some districts this may enable the growers to avoid the necessity for washing their fruit to remove excess arsenical residue. In the Northwest, however, it merely serves to reduce the quantity of residue to the point where it may more readily be removed by washing. The addition of the summer oils to lead arsenate also seems to result in a more effective spray than either material alone; but the use of this combination must be restricted to the early part of the season, for if used throughout the season serious difficulty may be encountered in the removal of the spray residue at harvest time.

The oils which have proved most satisfactory are considerably lighter than those used for dormant spraying, ranging in viscosity from 55 to 75 seconds. The degree of refinement (technically termed "the unsulphonated residue") ranges from 85 to 100 per cent.

Most of the work with summer oil sprays has been done on apple, which seems to be much more resistant to oil injury than peach. The use of an oil spray in combination with, or shortly after, the application of a sulphur fungicide is very likely to result in serious injury to the foliage, a factor which tends to limit the use of oils in localities in which sulphur fungicides are needed throughout the greater part of the season. At present the investigators in the Northwest recommend that not more than three applications of oil be made in one season. Much further experimental work with oils on all kinds of fruit trees will be needed before their exact place in the summer spray program will be established.

SOAP SPRAYS

Soaps are not only extensively used for making oil emulsions, but solutions of various kinds of soap are often used for the destruction of soft-bodied sucking insects, particularly aphids, the pear psylla, certain plant bugs, etc., and soaps are also frequently combined with other spray materials to cause them to spread and adhere to the foliage better.

FISH-OIL SOAPS

The commercial fish-oil soap, formerly known under the trade name of "whale-oil soap," is usually made from fish oils combined with either caustic soda or potash and contains varying proportions of water. An average grade of a soda fish-oil soap should contain, in addition to 30 per cent of water, about 10 per cent of caustic soda, 58 per cent of fatty matter as anhydrides, and about 2 per cent of other matter. Soda fish-oil soap is generally of medium to hard consistency and should be sliced to facilitate its being dissolved in hot water. It is brownish in color, with a distinct fishy odor. The potash fish-oil soap, much used as an emulsifier in the preparation of oil sprays, is a thick liquid containing from 60 to 70 per cent of water, and only from 30 to 40 per cent of soap. This material flows rather freely and is very convenient to handle.

For foliage sprays 1 pound of fish-oil soap is dissolved in 3 or 4 gallons of water, or at greater dilutions, depending upon the insects to be treated, the hardiness of the foliage, the proportion of actual soap in the product, and the hardness of the water which

must be used in diluting the spray. This last factor is of considerable importance in many fruit districts. Soft water should be used if possible when spraying with soap, since hard water destroys the insecticidal value of a portion of the soap. In case the only available water is hard, the proportion of soap must be increased, the exact increase varying with the degree of hardness of the water. For the dormant treatment of scale insects 2 pounds for each gallon of water is used and it should be applied while hot. Soda soaps, especially when used in this proportion, are likely to solidify upon cooling and clog the spraying apparatus.

Fish-oil soaps may be used with the following spray materials to increase their spreading and adhesive qualities: Lead arsenate, nicotine solutions, Bordeaux mixture, and sulphur. Soap should not be used in lime-sulphur solutions, or in waters strongly alkaline.

TOBACCO FISH-OIL SOAP

Commercial fish-oil soaps containing small percentages of nicotine are sometimes sold for insecticidal purposes. Soaps of this kind are somewhat expensive, and their use is scarcely justified unless the nicotine is present in sufficient quantity to have distinct insecticidal value, namely, from 0.05 to 0.06 per cent in the completed spray.

RESIN FISH-OIL SOAP

Commercial resin (rosin) fish-oil soaps are often used in the proportion of from 2 to 3 pounds to 50 gallons of spray to increase the adhesiveness of the spray material, especially on plums, grapes, and cranberries. They may be employed with lead arsenate, Bordeaux mixture, and nicotine solutions with satisfactory results. When applied alone as a soap spray, they should be used at about the same strength as fish-oil soaps. Resin potash fish-oil soap has also been found useful in preparing the cold-stirred soap-oil emulsion. (See p. 18.) The resulting product has the advantage of being quite stable in hard water.

HOUSEHOLD SOAP

In the absence of fish-oil soaps, ordinary soap often may be used effectively where only a few plants are to be treated. An average soap should be employed on plants in foliage in the proportion of 1 pound to from 2 to 4 gallons of water, according to the kind of soap and the insects to be treated.

TOBACCO OR NICOTINE INSECTICIDES

Nicotine in solution, obtained from tobacco, has long been recognized as an effective agent for the destruction of many soft-bodied sucking insects, particularly aphids, pear and other thrips, pear psylla, etc. Nicotine solutions are especially valuable as contact sprays, since they can be applied at the required insecticidal strength without injury to the foliage. Moreover, nicotine extracts may be combined with many of the standard stomach poisons and fungicides without depreciating their value. These combination sprays are much used when it is desired to treat at one time certain sucking and biting insects and fungous diseases.

Commercial nicotine, extracted from refuse tobacco, is sold on the market in several grades and strengths. A highly concentrated preparation, containing 40 per cent of nicotine, is at present being used extensively. The diluted spray material should contain not less than 0.05 or 0.06 per cent of nicotine, and in orchard spraying nicotine sulphate (40 per cent nicotine) is used in the proportion of about three-fourths of a pint to 100 gallons of spray. For small spraying operations use about three-fourths teaspoonful to a gallon, or 1 fluid ounce to 8 gallons, of soapy water. (See dilution table, p. 61.)

Soap should always be used with nicotine sulphate unless it is already combined with some other alkaline material, such as Bordeaux mixture or lime-sulphur. Some investigators have found that, in addition to causing the spray to spread and adhere better, the soap or the fungicide liberates free nicotine, thus making the spray more effective.

TOBACCO DUST

Tobacco dust has long been recommended for the control of the woolly apple aphid (*Eriosoma lanigerum* Hausm.) on the roots of the apple and for other root-inhabiting insects, and to a less extent for dusting low-growing plants, such as currants and gooseberries, for the destruction of aphids.

The effectiveness of tobacco dust as a treatment for the woolly aphid on the roots of the apple varies with the amount of nicotine in the dust and its fineness and the character of the weather. Abundant moisture in the soil, as from irrigation or rains, leaches out the nicotine, which then destroys the insects to a greater or less extent. Where tobacco dust may be obtained cheaply its use is warranted for the woolly aphid, but the purchaser should assure himself that the dust is not the grade sold for fertilizer purposes from which the nicotine has been extracted. In addition to its insecticidal value, tobacco dust has a considerable fertilizer value.

Nicotine is sometimes also applied in a dust carrier, the dust being prepared by thoroughly mixing nicotine sulphate (40 per cent nicotine) solution with about twenty times it weight of hydrated lime. A homemade mixer for preparing nicotine dust is shown in Figure 5, taken from Farmers' Bulletin 1499,[10] The Melon Aphid and Its Control, to which the reader is referred for more complete instructions on the preparation of nicotine dusts.

To have maximum effectiveness, nicotine dust should be used when the temperature is above 70° F., at a time when the foliage is dry, and when there is a minimum of air movement. Since the operation is essentially an open-air fumigation, and most of the killing is done by the liberated nicotine in the form of a vapor, even a slight movement of air will carry the vapor away before it has time to affect the insect. Because of the difficulty experienced in finding air conditions satisfactory for their application, nicotine dusts have never come into very general use in the control of orchard insects, although on low-growing crops they have proved quite successful.

[10] The bulletin may be obtained free upon application to the U. S. Department of Agriculture.

DERRIS EXTRACTS

Extracts of the roots of Derris, a tropical plant used by the natives of the East Indies as a fish poison, are used to some extent as contact poisons against many soft-bodied insects and are fairly effective for this purpose. These extracts are available chiefly as proprietary materials, which are of such strength that they should be diluted on much the same basis as are the commercial nicotine extracts. The active principles in Derris are practically nonvolatile and do not cause the discomfort sometimes experienced by spray men in applying nicotine.

PYRETHRUM EXTRACTS

Pyrethrum (*Pyrethrum cinerariaefolium* Trev. and closely related species) has long been known to possess insecticidal qualities, and the

FIGURE 5.—Homemade ball mill for mixing nicotine dust

pulverized dried flower heads have for many years formed the basis of certain insect powders. In recent years, more or less standardized extracts of pyrethrum have been used as household sprays against flies and other insects. A number of proprietary extracts prepared for the spraying of plants are now on the market, and these possess considerable value as contact materials against soft-bodied insects. The various brands differ greatly in the method of extraction and preparation of the pyrethrum, as well as in the proportions of the active ingredients present. The directions given on the label of the container should be followed as to the strength to use for different insects.

OTHER MATERIALS USED IN SPRAYING

Several other materials, which can not be classed exactly with either the stomach poisons or the contact materials, are often used

in spraying for the control of insect pests, either for their direct insecticidal value, or in conjunction with insecticides.

BORDEAUX MIXTURE

Although essentially a fungicide, Bordeaux mixture is sometimes recommended as a repellent to insects and is said to have considerable value in the control of certain leaf hoppers. One formula for making Bordeaux in quantities of 50 gallons and 5 gallons is inserted here, since this material is several times referred to in the spraying schedules for apple and grape for the combined treatment of diseases and insects.

50-gallon lots

Copper sulphate (bluestone)	pounds	4
Fresh stone lime	do	4
(Or hydrated lime)	do	6

5-gallon lots

Copper sulphate (bluestone)	pound	½
Fresh stone lime	do	½
(Or hydrated lime)	do	¾

A Bordeaux of this strength is referred to as a 4–4–50 mixture, the first figure referring to the number of pounds of copper sulphate, the second to the number of pounds of stone lime, and the third to the number of gallons of water.

DIRECTIONS FOR MAKING

A stock solution of bluestone is made by dissolving it in the proportion of 1 pound to 1 gallon of water. The bluestone should be suspended in a cloth sack in a barrel, or other nonmetal container, so that it is just beneath the surface of the water. The crystals will be dissolved if left for a few hours in cold water and in a shorter time in hot water. A stock milk of lime may be made by slaking the lime in a little water and then further diluting it so that each gallon contains 1 pound of lime. If hydrated lime is used, it should be worked into a thin paste and diluted in a similar manner. Just before the stock solutions are used they should be stirred thoroughly.

Bordeaux mixture was formerly made by diluting each ingredient with about half the total volume of water to be used and then running the two simultaneously into the spray tank, a method which necessitated rather extensive mixing apparatus, with elevated tanks and platform. For mixing small amounts this method is very convenient. At present most of the mixing of Bordeaux is done directly in the spray tank. It seems essential, however, to have one or the other of the ingredients in a dilute form before the two come into contact with each other. One mixing method in common use is to fill the tank from two-thirds to three-fourths full of water, add the copper sulphate solution (with the agitator running), then the milk of lime, and, finally, complete the filling of the tank with water. Recently there has appeared on the market a finely pulverized copper sulphate that goes into solution very rapidly. This may be dissolved by washing it through the screen (which should be of copper or brass) while the tank is being filled. By the time the

tank is nearly full the bluestone will be completely dissolved, and the lime may then be added as previously described. Bordeaux mixture deteriorates on standing and should therefore be used as soon as possible after it is mixed.

For early summer spraying the quantity of bluestone may be reduced to 3 pounds, or even less, to reduce the danger of russeting the fruit. Bordeaux mixture for grape spraying is made up of 4 pounds of bluestone and 3 pounds of stone lime in 50 gallons of water.

Prepared Bordeaux mixtures are on the market, both in the form of a paste, and in dry, powdered form.

LIME

In addition to being an essential ingredient of Bordeaux mixture, lime finds many other uses in the insect-control program. It is used as a corrective with arsenicals to combine with any soluble arsenic which may be present, or which might be liberated. In peach spraying the addition of lime to lead arsenate is absolutely necessary to reduce foliage injury, and in many sections lime is similarly used in apple spraying. Usually from 2 to 4 pounds of hydrated lime or the equivalent in stone lime are used with each pound of lead arsenate.

Hydrated lime is a well-known commercial product made by slaking stone lime with water. The excess water is then evaporated, leaving dry hydrated lime. This should not be confused with air-slaked lime. For many purposes either stone lime or hydrated lime may be used, three-fourths of a pound of stone lime being equivalent to 1 pound of hydrated lime.

In the process of manufacturing hydrated lime, three grades are produced. The coarsest is known as agricultural hydrated lime, the medium grade as mason's hydrated lime, or finishing lime, and the finest as chemical hydrated lime. The medium grade is more readily available but contains considerable quantities of grit, which causes excessive wear to spray pumps and nozzles. The finest grade, or chemical hydrated lime, costs a little more but is more satisfactory for spraying purposes if it can be obtained.

Hydrated lime is much used as a filler in the preparation of dusting materials, being added to increase the bulk of the dust, and thus reduce the strength of the active and more expensive ingredients, as well as to reduce the danger of foliage injury when arsenicals are used.

Hydrated lime has also been found recently to have a certain direct value in insect control, acting as a barrier and deterrent to newly hatched oriental fruit-moth larvae. The quantity required to give an appreciable degree of control is so great, and the application is of necessity so late, that an unsightly (though nonpoisonous) residue may be present on the harvested fruit. This residue, together with the resulting poorer color of the fruit, materially lessens its market value.

SPREADERS AND STICKERS

A great many materials have been recommended from time to time for use in spray mixtures for the purpose of causing the spray to spread better over the foliage and fruit, or to improve its sticking

qualities, or both. The various soaps are used with many spray mixtures for this purpose. Soaps sometimes cause difficulty by foaming and frothing, thus keeping the pump from maintaining the proper pressure. Soaps are incompatible with certain sprays, especially with lime sulphur, and are also to a considerable extent wasted when used with very hard waters.

CASEIN-AND-LIME SPREADERS

The spreader in most common use is a mixture of casein and lime, often referred to as calcium caseinate. Several of these spreaders have been widely advertised, and rather broad claims have been made for them. The available experimental evidence, however, seems to indicate that the indiscriminate use of calcium caseinate in all spray applications is not worth while, and under some conditions may even be undesirable. This material, however, has several important uses in orchard spraying. It serves as an emulsifier for oil sprays (p. 20), and is used in the preparation of dry-mix sulphur lime (p. 16).

Calcium caseinate should not be stored over too long periods, especially if exposed to the air. If so exposed the hydrated lime in it gradually becomes air-slaked, and the mixture loses much of its value.

FISH OIL

Fish oil has been found by Hood [11] to be a very effective sticker for lead arsenate, and several other workers have reported favorably on the use of this material for the spraying of apples and grapes. The recommendations call for 3 fluid ounces (a little less than a half cup) for each pound of insecticide. The fish oil is merely poured into the spray tank when it is nearly full, and in a power outfit is emulsified by the action of the agitator. With smaller spray outfits it is sometimes necessary to pump the liquid back into itself a few minutes to mix in the fish oil. In buying fish oil for use in orchard spraying, the fruit grower should specify a "choice, light-pressed menhaden oil" having less than 5 per cent of free fatty acid. Linseed oil may be used for the same purpose and is more pleasant to handle, but is more expensive.

The use of fish oil should be restricted to the early part of the season, since, if applied with lead arsenate late in the season, it may cause excessive spray residue at harvest time.

FUMIGANTS

FUMIGATION OF NURSERY STOCK

Fumigation of trees from the nursery before planting, and of buds, grafts, etc., for the destruction of scale insects, aphids, and other nursery pests is practiced by some orchardists and nurserymen.

FUMIGATION BOXES

When large quantities of nursery material are to be fumigated, as by nurserymen, specially constructed fumigation houses are used, but fumigation boxes of various sizes are employed for smaller opera-

[11] U. S. Department of Agriculture Technical Bulletin 111, Fish Oil as an Adhesive in Lead-Arsenate Sprays. 28 p., illus. 1929.

tions, as by orchardists. These boxes, of any convenient size, as 6 feet long, 3 feet high, and 3 feet wide, may be made of two thicknesses of lumber, such as plain matched ¾-inch ceiling, flooring boards, double-matched sheathing, etc. Between the two layers of boards should be placed a double thickness of tarred paper. Near the bottom of the box should be placed a few cross pieces or slats, on which to lay the nursery material, sufficient space beneath being allowed for the generator. The box should be strongly reinforced at the corners and at other necessary places, and on one side of the box, at the bottom, a small door or opening which can be tightly closed should be provided for the admission of the generating receptacle and chemicals. The top or lid should be fitted to close very tightly against a felt weather strip. In place of a complete fumigation box some growers use a box without a top, inverted bottom upward on the ground, the earth being packed tightly around the edges to prevent the escape of the gas. Whatever may be the type of box, it must be as nearly air-tight as possible and kept in that condition by necessary repairs. It will be well to give the box two coats of paint inside and out each year.

The most effective fumigant is hydrocyanic acid gas. This is extremely poisonous and if inhaled may prove fatal. Preferably it should be used by experienced operators and every precaution taken not to breathe any of the gas. Great care should also be taken to keep all chemicals accessible only to those using them, as the cyanides are very poisonous and the sulphuric acid extremely caustic.

Hydrocyanic acid gas, if properly used, will not injure well-matured dormant nursery stock, neither will immature material, as buds, be damaged by effective quantities of the gas. The material to be fumigated should be reasonably dry and separated somewhat so that the gas may surround it thoroughly.

CYANIDE FUMIGATION BY POT METHOD

SUPPLIES

For cyanide fumigation by the pot method the following supplies are required, and the chemicals should be of the grade given below:

Sodium cyanide (96 to 98 per cent), containing 51 to 52 per cent of cyanogen. When purchasing cyanide for fumigation purposes, this grade, which is known as fumigation cyanide, should always be specified.

Sulphuric acid. This should be a high-grade commercial product testing about 66° Baumé (1.84 specific gravity).

Generating vessel. An earthen crock, china dish, or bowl may be used as a receptacle for the water and acid. Do not use a tin or iron vessel of any kind, as the acid will corrode these metals.

FORMULAS

The formula to be used will depend upon the character of material to be fumigated, dormant trees and grafts being given a heavier dosage than buds.

Formula for dormant trees and grafts

Sodium cyanide	ounce	1
Sulphuric acid	fluid ounces	1½
Water	do	2

Formula for buds

Sodium cyanide	ounce	½
Sulphuric acid	fluid ounce	¾
Water	do	1

Either of the above formulas produces the proper volume of gas for 100 cubic feet of inclosed space. The quantities of ingredients should be decreased or increased in proportion for smaller or larger boxes. A box of the size mentioned on page 30 would require about one-half these quantities of materials.

PROCESS OF FUMIGATION

After the material to be fumigated has been placed in the house or box, and everything is in readiness, put the generator jar or jars in place with the necessary water. Then pour the acid very slowly into the water. Never pour the water into the acid, as this procedure causes considerable spattering of the acid. Next weigh out the cyanide and place it in a small paper sack and then gently drop it into the generator. The operator must close the box or leave the house at once. Where several generators are to be used, as in a large fumatorium, the sacks of cyanide should be lowered into the generating vessels by means of strings operated at the door. By taking this precaution the operator will avoid any possibility of inhaling the deadly gas. The material should be fumigated for a period of from 45 minutes to 1 hour.

In fumigating houses or large chambers, facilities for opening the doors and windows from the outside must be provided so as not to expose the operator to the fumes. No one should enter the fumatorium until all the gas has been liberated by thorough ventilation.

CALCIUM CYANIDE FUMIGATION

The fumigation method outlined above, requiring the use of sodium cyanide and sulphuric acid, has been replaced to some extent by the use of calcium cyanide, a compound which liberates hydrocyanic acid gas when it comes into contact with the moisture in the air. Calcium cyanide is available in several forms, the most satisfactory of which is a fine dust. This material is merely blown or sprinkled over the floor of the fumigating chamber which is then tightly closed for a period of several hours. Judging by recent work from one-half to 1 ounce for every 100 cubic feet of space to be fumigated is ample. The humidity must not be too low or there will not be enough moisture in the air to liberate all of the gas. In case the fumigation chamber is very dry, some moisture should be provided by sprinkling the walls with water, or by adding masses of moistened newspapers. The quantity of water supplied, however, should not be so great that actual drops of moisture are present at the time of fumigation.

Calcium cyanide dust has also been used in an experimental way as an open-air fumigant in the control of such sucking insects on deciduous fruits as the grape leaf hopper (*Erythroneura comes* Say), pear psylla (*Psyllia pyricola* Först.), and apple leaf hopper (*Empoasca mali* LeB.). While considerable numbers of the insects may be killed under ideal conditions, this method of control has never come into practical commercial use. Dusting with calcium cyanide is sub-

ject to the same requirements as apply to the use of nicotine dust on deciduous-fruit trees (p. 25), except that high temperatures are not so essential to effective work.

PARADICHLOROBENZENE

Paradichlorobenzene, first tested as a soil fumigant by E. B. Blakeslee, of the Bureau of Entomology, is now in very extensive use in the control of the peach borer (*Synanthedon exitiosa* Say), and of a few other species. Paradichlorobenzene is a white crystalline material, somewhat similar in general appearance to granulated sugar. This chemical gradually vaporizes, the odor of the vapor being somewhat like that of naphthalene. At 77° F. the mixture of paradichlorobenzene vapor and air is about one-half of 1 per cent heavier than air. The gas is toxic to insects, although its action is very much slower than that of hydrocyanic acid gas. Paradichlorobenzene should be about the fineness of granulated sugar, since the coarser grades vaporize too slowly for best results. Paradichlorobenzene should be stored in air-tight containers to avoid loss by evaporation.

Only unadulterated paradichlorobenzene should be bought, for if a filler has been added the actual strength of the material is further reduced to an unknown extent if any of the active ingredient evaporates before the chemical is applied. The composition of such material is thus uncertain, and if it has been exposed over a long period of time, the mixture may consist chiefly of valueless inert filler.

Directions for the use of paradichlorobenzene are given in a later section of this bulletin (pp. 77–78).

DIPPING NURSERY STOCK

Some nurserymen and fruit growers dip nursery stock, scions, and bud sticks in order to insure as much as possible the destruction of any insects which may be present. The treatment is especially aimed at the San Jose and other scale insects and the woolly apple aphid on apple. The principal dips are: Lime-sulphur concentrate (33° Baumé), 1 part to 7 parts of water (at temperatures of 60° to 120° F.); 2 to 4 per cent lubricating-oil emulsion; or the miscible oils, 1 part diluted with 10 to 15 parts of water. The dipping method is not so effective as fumigation with hydrocyanic acid gas (p. 29) and, further, may cause injury, depending upon the maturity and hardiness of the plants treated. The roots of nursery trees can not be dipped with safety in the lime-sulphur solution. Entire trees, however, may be immersed in the oil emulsions with less danger of injurious results.

WORMING FRUIT TREES

A very effective method of reducing injury to fruit trees by certain borers, as the peach and apple tree borers, is to "worm" the trees regularly in the spring and fall of each year. (Fig. 6.) Previous to worming, the earth should be removed from around the crown of the tree to a depth of 4 or 5 inches and the trunk brushed or scraped free of bark and loose dirt. With a little experience the

worker can readily locate the borers in their burrows and remove them by means of a knife, stiff wire, or other suitable tool.

A combined scraping and gouging instrument is used in the South and is reported to be a valuable tool in worming. A piece of steel bar is flattened out along about two-thirds of its length into a dull blade 2 or 3 inches wide and gradually tapered to a point. The point is bent out and slightly upward to form a hook for gouging the insects in their burrows. The other end of the blade is fastened firmly into a 12 or 14 inch piece of wood for a handle, as a section cut from an old hoe or shovel handle. The whole tool is not more than 17 or 20 inches long. Figure 7 shows the tools which are suggested for use in digging out roundheaded apple-tree borers.

FIGURE 6.—Large-scale worming of peach trees in a Georgia orchard. Except on young trees, this method of controlling peach borers has been largely replaced by the use of paradichlorobenzene

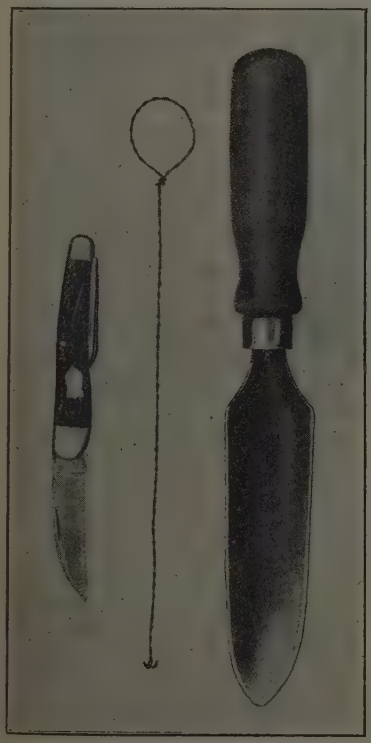

FIGURE 7.—Tools suitable for use in removing roundheaded apple-tree borers from their burrows

In worming, care should be taken not to cut the sound bark or wood more than necessary, and the cutting should be done vertically. Carelessness in the use of worming tools may result in more damage to the trees than would be caused by the insects. After the trees have been wormed it is desirable, if practicable, to go over them again a few days later, when the location of any larvae missed during the first examination will usually be indicated by the exuded frass. After the worming has been completed the earth should be replaced around the trees, and in the case of spring worming of peach trees it should be mounded around the base of the trunk to a height of 8 to 10 inches. (Fig. 8.)

This will cause the borers to enter the bark somewhat higher and facilitate their detection and removal. If washes or wrappings are used, they should be put on at

once after the spring worming and before the earth is replaced around the trees. Failure to replace the earth around peach trees after a late fall worming is often followed by severe winter injury to the collar of the tree.

PROTECTIVE AND CAUSTIC WASHES FOR BORERS

Washes of various materials have been recommended for use on fruit trees to repel adult insects that would deposit eggs or to prevent the entrance into the bark of newly hatched larvae. These washes are to be applied after the spring worming and before the adult insects have issued and begun to deposit eggs. Certain caustic washes have also been recommended for use at the time of fall worming to destroy by contact any of the young larvae that may have escaped the hooking and worming methods. As has been stated, reliance for borer control should be placed on worming, or, in the case of peach trees, on the use of paradichlorobenzene, washes being used merely as an adjunct.

FIGURE 8.—Application of whitewash and mounding of earth around peach-tree trunk against peach borer. Mostly superseded by the use of paradichlorobenzene

LIME-SULPHUR CONCENTRATE

Lime-sulphur concentrate (33° Baumé), 1 part to 6 or 7 parts water, to which a large excess of lime has been added, is used by some as a deterrent to borers. It is also reported as valuable in protecting trees from attack by mice and rabbits.

ARSENICALS IN BORER WASHES

Lead arsenate or Paris green is sometimes mixed with a wash with the idea of poisoning the larvae which attempt to eat through it. Arsenicals in washes or paints are used with considerable risk of injury to the trees.

PAINT

Probably the best wash for apple-tree borers is a thick coat of paint, made from raw linseed oil and pure white lead. Remove a layer of soil 3 or 4 inches deep from the base of the tree, scrape off the dirt and loose bark scales, and after worming apply to the

exposed trunk a thick, uniform coating of the paint to a distance of about 1 foot above the ground. Worming and painting should be done annually in the early part of May, before the beginning of the egg-laying season of the parent beetles. White lead paint has sometimes caused injury, probably on account of inferior ingredients.

GOVERNMENT WHITEWASH

A heavy whitewash, known as the Government formula for whitewash, has been employed with more or less success on trees recently attacked by the fruit-tree bark beetle (*Scolytus rugulosus* Ratz.) (p. 78). It is prepared as follows:

Stone lime	bushel	½
Salt	peck	1
Ground rice	pounds	3
Spanish whiting (plaster of Paris)	pound	½
Glue	do	1
Water	gallons	5

First slake the lime with warm water and then strain it through a fine sieve or strainer. Dissolve the salt in warm water, boil the rice flour to a thin paste, and dissolve the glue in boiling water. Mix the ingredients in the following order and stir well: Pour the salt solution into the lime, then the rice paste, and next stir in, boiling hot, the Spanish whiting and glue, and finally add hot water to make up the 5 gallons of water called for. Stir thoroughly and let it stand for a few days. It should be applied hot with a brush.

MECHANICAL TREE PROTECTORS

Tree protectors of various materials and styles have been long recommended and are more or less used by orchardists. They are intended principally to protect peach, apple, and other fruit trees from attack by borers, mice, and rabbits. They are placed around the tree trunk and extend from a few inches below the surface of the ground to a foot or more above the ground level.

Heavy wrapping paper and tarred paper wrapped around the tree trunk and securely tied with strong twine have been used extensively, as well as protectors made of wooden veneer. Cylinders of wire screening are employed with the idea of preventing the adults of apple-tree borers from depositing their eggs on the lower part of the tree. Close-mesh wire fencing material is also used to keep away rabbits and mice. Repeated trials of various tree protectors have shown that they can not be depended upon to exclude borers to a satisfactory degree, though they are of value against rodents. Hence, if protectors are used and the trees are not regularly wormed, they are likely to become badly infested, the protectors frequently furnishing an ideal retreat for the insects.

A very large number of tree protectors have been patented, but none of these has shown sufficient merit to lead to its adoption to a general extent by orchardists.

BANDING FOR THE CODLING MOTH

Banding the trunks and larger limbs of apple trees with strips of cloth or other materials has been practiced extensively for the

control of the codling moth. Previous to the advent of spraying the banding method was the best means known of checking the ravages of this pest, and the bands are still used as an adjunct to spraying in regions heavily infested with the codling moth. This method consists in fastening a band of cloth or other material around the trunk, from which the loose bark has been removed. Usually a band made from burlap folded to three thicknesses from 4 to 8 inches wide is used. A heavy tarred building paper or light roofing paper has also been used somewhat successfully in certain localities. Strips of corrugated paper are very attractive to the worms, but bands of this material must be destroyed and replaced with new ones eight or ten times a season. The codling-moth larvae, or worms, crawl beneath the band to form their cocoons, and these should be destroyed by hand at intervals of 10 days throughout the season.

The Bureau of Entomology has recently worked out a chemical treatment of corrugated paper bands which renders them automatic, the chemical killing practically all worms which enter them. The material found most effective for this purpose is known as beta-naphthol (technical grade), and the bands are coated with a hot lubricating-oil solution of the chemical. This subject is still under investigation, and further details will not be given here. The chief value of the chemically treated bands is in the elimination of the necessity for hand labor during the busy summer season. Hand-worked bands are sometimes neglected during the rush of other operations and under such conditions do more harm than good.

FIGURE 9.—Wheelbarrow curculio catcher. Useful on small trees, such as plums, cherries, and quinces

JARRING INSECTS FROM THE TREES

Certain insects, notably the plum and quince curculios (pp. 67, 76, 77), may be much reduced in numbers by regularly jarring the trees in the early spring and collecting the insects on sheets or special cloth-covered or metal frames. The curculios have a habit of feigning death whenever they are disturbed, and dropping to the ground. Jarring peach and plum trees was at one time the principal method of control of the plum curculio and is still used to some extent as a supplement to spraying in the control of severe infestations.

In the control of the quince curculio jarring is also still practiced. The work is usually started early in the morning while the insects are sluggish and easily dislodged. A wheelbarrow umbrella catcher (fig. 9) is usually employed, though the curculios may be collected

on sheets placed on the ground or held beneath the trees. A heavy rap with a padded wooden mallet serves to bring the beetles down. In using the specially designed wheelbarrow umbrella catcher the tree is shaken by striking the trunk with a bumper on the framework of the wheelbarrow at the base of the slit in the umbrella. The beetles slide by gravity to the center of the umbrella into a receptacle containing oil.

BAGGING FRUITS

Choice fruits, especially grapes, may often be protected from insect pests by the use of paper bags placed around the bunches and securely fastened to the supporting shoot or cane. This method is suitable for small vineyards and arbors in reducing injury from the grape-berry moth (*Polychrosis viteana* Clem.), the rose chafer (*Macrodactylus subspinosus* Fab.), and the green June beetle (*Cotinis nitida* L.), but it is too expensive for use on a commercial scale. Bags may be put in place as soon as the blossoms have fallen.

INSECT DESTRUCTION BY FIRE

Gregarious insects, as the eastern tent caterpillar (*Malacosoma americana* Fab.), the fall webworm (*Hyphantria cunea* Drury), and others, can be destroyed in their nests by means of a torch. A handful of rags fastened to a pole and soaked in kerosene will serve for this purpose. The nests should be burned while the caterpillars are at rest within, care being taken not to injure the larger limbs and branches. Egg masses of the gipsy moth and of other insects, deposited on stone walls and in similar situations, can be destroyed by burning with suitable blast or other torches. Cranberry bogs are sometimes burned over in order to destroy certain insects such as the cranberry girdler. This is usually done by specially constructed torches. Leaves and trash in orchards, which frequently harbor injurious insects, should be well plowed under to add to the humus in the soil, or raked up and burned during the fall, winter, or early spring. Great care should at all times be taken not to let the fire get beyond control, as much damage may result to the orchard, as well as to woodlands, buildings, or other property.

BAITS FOR THE CONTROL OF INSECTS

The codling moth and the oriental fruit moth (*Laspeyresia molesta* Busck) may be attracted in large numbers to fermenting solutions of sugar, molasses, malt sirup, and fruit juices, as well as to certain aromatic chemicals. In attempting to feed upon these liquids, many of the moths fall in and drown. Various types of containers have been used, the chief ones being a 1½ or 2 quart stewpan, a gallon-size tin container (painted inside and out to prevent rusting and chemical reactions with the bait materials), and quart glass jars. The stewpan type of container probably attracts the largest number of moths, but evaporation is very rapid, and there is also a considerable loss of bait material in high winds. The glass containers keep the solution in good condition for a longer period of time and do not permit so much loss of material by wind. The

baits should be placed as high as possible in the tree, preferably where the foliage is scanty or lacking. In cool weather yeast is sometimes added to the sugar-containing solutions in order to speed up fermentation. Although large numbers of moths may be captured, the value of the traps in control has not yet been established. In the Northwest the bait pans are depended upon for information as to the periods when codling moths are active in the orchards and are invaluable in the timing of spray applications.

FIGURE 10.—Japanese beetle trap. The beetles, attracted by the geraniol bait, fly to the trap, strike the baffle plates, and drop through a funnel into the glass jar below

A substance known as geraniol has been found to be very attractive to the adults of the Japanese beetle (*Popillia japonica* Newm.), drawing them for distances as great as half a mile. This material has been utilized in traps (fig. 10) designed to capture the beetles and also for the purpose of concentrating the beetles on some valueless vegetation where they may be killed by spraying with a strong contact material.

INSECT LIGHT TRAPS

It is a well-known fact that certain insects are attracted at night to lights, and in an effort to take advantage of this habit, insect light traps have been recommended at various times for the capture of injurious species. Some of the traps developed are very simple, and others are more elaborate patented contrivances. The small forms consist of an ordinary lantern placed over a basin containing water which is covered by a thin film of kerosene or other oil. The insects in fluttering about the light fall into the oil and are destroyed.

Experiments with light traps in orchards have indicated that these have only slight, if any, value in orchard-insect control. The light traps capture some injurious forms, but at the same time destroy a good many beneficial parasitic and predacious species. Many orchardists have been induced to purchase light traps which were guaranteed to capture the codling moth. This insect, however, has been attracted but little to any light traps thus far devised.

INJECTIONS INTO TREES

Claim is occasionally made, in circular matter issued by financially interested persons and in other ways, of the efficacy in insect and disease control of substances or compounds inserted into holes bored into trees or placed under the bark. Wonderful results have been claimed in some instances from such treatments, and some orchardists and numerous owners of a few yard trees have been induced to have their trees inoculated. No injection treatment has yet been devised that will kill insects without at the same time causing serious injury to the tree. Figure 11 illustrates the injury to a tree resulting from placing under the bark a small quantity of a mixture containing sodium cyanide, common salt, and certain other ingredients.

FIGURE 11.—Injury to an apple tree resulting from injection of a cyanide mixture under the bark

TREE-BANDING MATERIALS

Bands of sticky material, 4 to 5 inches wide, applied around tree trunks sometimes may be used to advantage to prevent caterpillars, climbing cutworms, and certain other insects from climbing the trees. These bands are also employed to prevent nonflying and wingless moths, such as the gipsy moth, cankerworm moths, tussock moths, etc., from ascending trees to deposit their eggs. Cotton batting and wire screen also are used in making protective bands.

The indiscriminate use of these bands, as well as of mechanical barriers, is to be discouraged. They are sometimes seen in parks on trees which are not subject to attack by insects against which they would have any value. As a rule it is advisable to obtain advice as to their use from entomologists.

These sticky bands are sometimes injurious to the tree, but injury may be avoided by spreading the adhesive on a strip of heavy paper encircling the tree trunk. A form of band that has given satisfactory results is made from cheap cotton batting and single-ply tarred building paper. The cotton should be cut into strips about 2 inches wide and wrapped around the tree trunk so as to fill all the crevices of the bark. Over the cotton is placed a strip of tarred paper about 5 inches wide, drawn tightly and securely tacked where it overlaps. The sticky material is then spread on top of the paper. (Fig. 12.)

The sticky substance must be renewed from time to time, since when it dries out or becomes covered with dust or insects it fails as a barrier to crawling insects. If a combing instrument is occasionally drawn over the band, it will serve to lengthen the usefulness of the band by bringing some of the sticky portion to the surface.

Sticky fly paper is used sometimes in place of the sticky bands. This may be attached to the trunk by means of heavy twine tied tightly around the upper and lower edges and serves best if put over a strip of cotton as just described.

AXLE GREASE, FISH OIL, AND ROSIN BANDING MATERIAL

A tree-banding material used in Europe, reported as effective, is made as follows:

Axle grease	pound	1
Fish oil	pint	1
Powdered rosin	pounds	2

FIGURE 12.—Barrier of sticky material on tree trunk to prevent ascent of caterpillars, wingless moths, etc.

Heat the axle grease, to remove all of the water contained therein, in a cooking vessel having a capacity of at least 1 gallon. Then stir in the fish oil and finally the powdered rosin a little at a time. When the latter is dissolved, remove from the fire. The mixture is ready for use the next day. Apply to tarred-paper bands as already described.

GIPSY MOTH TREE-BANDING MATERIAL

The preparation of a tree-banding material which has been developed for use in the control of the gipsy moth is described in detail in United States Department of Agriculture Bulletin 899, Gipsy Moth Tree-Banding Material: How to Make, Use, and Apply It, which should be consulted by any fruit grower who has occasion to use large quantities of sticky banding material. The bulletin may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. Price 15 cents.

Several other sticky substances, homemade and proprietary, are used.

PRINTER'S INK

Printer's ink which is sold as "tree ink" usually consists of refuse ink and should be mixed with a heavy oil to prevent its drying out too quickly. Apply as described for other tree-banding materials.

COTTON BATTING

Barriers other than sticky bands are sometimes used to prevent insects from crawling up trees. Bands of cotton batting about 6 to

8 inches wide are effective as long as the cotton remains fluffy. Wrap the band around the tree trunk and securely tie the bottom edge by means of stout twine. The upper edge should then be turned down over the string, forming a flange of loose cotton all around the tree. (Fig. 13.)

WIRE SCREEN

Cankerworm moths, tussock moths, gipsy moths, and other nonflying moths may be prevented from crawling up the trees by a wire screen (ordinary fly screen, 12 meshes to the inch) tacked around the tree trunk. Cut the wire screen into strips 12 inches wide and sufficiently long to encircle the trunk. Tack the upper edge of the screen so that it fits snugly to the bark and allow the lower edge to extend out a distance of 1 to 2 inches from the trunk. The moths will crawl up into the screen trap and may be crushed daily by hand. This device, however, does not prevent the ascent of trees by any young larvae hatched from eggs deposited by the captured moths below the barrier, and hence the sticky bands are more effective.

FIGURE 13.—Barrier of cotton batting on tree trunk to prevent ascent of caterpillars, wingless moths, etc.

TREATMENT OF TREE WOUNDS

Wounds due to removal of large limbs, or to injury from any cause, as by rabbits, field mice, plows, etc., around the base of trees, should be promptly disinfected and treated with a waterproof covering. An exposed surface is subject to attack by fungi and invasion by wood-boring insects unless properly cared for. After a limb is cut off, the wound should be treated with a disinfectant, such as common creosote, which will penetrate and sterilize the wood. This may be applied with a small brush. After creosoting, the wood should be protected from moisture by means of a heavy coat of coal tar. Instead of using the materials separately, they may be combined as a mixture containing creosote and coal tar. Add enough creosote oil to the coal tar to bring it to the consistency of thick paint (approximately 1 part creosote to 3 parts of coal tar). One coat of the mixed materials may be sufficient, but, if not, a heavy application of the coal tar should be used, and the surface recoated whenever it is found cracking or breaking away from the wound. A pure white-lead and linseed-oil paint is sometimes employed for tree wounds, and, although not so satisfactory as the coal-tar-creosote paint, it is a good deal better than nothing. Ordinary grafting wax will give good results for small surfaces. A paint prepared by mixing dry Bordeaux with linseed oil has also been used for treating tree wounds.

TREATMENT OF TREE CAVITIES

Decayed cavities in the trunk or limbs are frequently infested with wood-boring larvae or are the retreat of different species of ants. Such cavities are objectionable, for not only do they favor gradual decay and weakening of the trees but also they afford an excellent winter harbor for such insects as the codling moth. As noted below, cavities in the trunk usually are the result of improper pruning and neglect to care for wounds from other causes. Such cavities should be cared for.

The first operation is to remove all the decayed wood. This can be done by means of a gouge, chisel, mallet, and knife. The cavity should be drained, either by cutting a V-shaped point at the bottom, where practicable, or by boring a small hole to serve as a drainage outlet. In cutting around the edge of the cavity nothing but very sharp tools should be employed, as dull instruments will injure the cambium. After the cavity has been thoroughly cleaned out it should be treated with the creosote-coal tar mixture as previously described. Repaint every year or two if necessary until danger from further decay has passed.

PRUNING

Twigs and branches of orchard trees, when heavily infested with or injured by insects, frequently can be removed in the course of pruning operations. Also in pruning thought should always be given to maintaining the shape of the trees to facilitate the application of sprays.

In cases of severe insect injury large trees sometimes should be severely cut back or "dehorned" in order to produce new healthy wood. This also brings the trees to a size more convenient for spraying. With old trees, however, too much wood should not be removed at one time, and the dehorning process should be extended over two or three years. Small limbs and twigs incrusted with scale insects or punctured by the periodical cicada (*Tibicina septendecim* L.), tree hoppers, or other insects, usually may be removed to advantage. Pruning should be done preferably before the application of dormant tree sprays, since it is a waste to use spray materials on limbs and branches that are to be removed later, and the spraying may be done more thoroughly after the removal of the excess wood.

All dead trees and limbs should be promptly removed and burned, as wood-boring insects breed in them and may become abundant enough to attack and injure near-by healthy trees. When limbs of trees are being removed, they should be sawed as close to the trunk as possible to insure rapid and complete healing over. Stubs of limbs should not be left, as these decay, later resulting in a cavity which permanently injures the tree and affords a hiding place for noxious insects. In cutting large limbs special care should be taken to prevent stripping of the bark from the trunk. A large limb is best removed by first sawing the limb from the underside at a distance of 6 or 8 inches from the trunk until the saw is pinched, by which time the cut should have reached from one-fourth to one-half through the limb. The second cut should be made on the upper side

of the limb an inch or two farther from the base of the limb than the first one, sawing being continued until the limb falls. It is then easy to saw off the stub close to the tree trunk, and in line with its woody surface, taking care, however, to support the stub until completely severed.

STIMULATION OF GROWTH BY FERTILIZATION

Unthrifty trees, vines, and other plants are thought to be more subject to the attack of certain insects than plants in a healthy condition. Weakened trees are frequently killed by wood-boring insects which do not attack trees growing vigorously. Such trees sometimes can be saved by prompt stimulation with a nitrogenous fertilizer, as nitrate of soda, stable manure, etc. This treatment, in connection with severe pruning and adequate cultivation, especially in the case of stone fruits, will often result in their marked improvement.

Cultivation late in the season, however, may stimulate a late growth, which is especially subject to winter injury. In the case of the peach orchard, too vigorous a late growth is also undesirable from the standpoint of the control of the oriental fruit moth, as it furnishes the insect with succulent young growth after harvest, when it might otherwise fail to find favorable food.

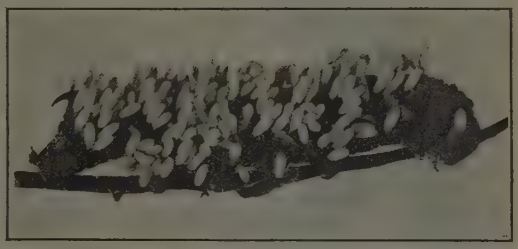

FIGURE 14.—Sphinx caterpillar bearing cocoons of a small, 4-winged, wasplike parasite. These cocoons are often mistaken for eggs. Slightly less than natural size

CULTIVATION

Many fruit-insect pests which pass part of their life in the soil, such as the plum curculio (*Conotrachelus nenuphar* Herbst), spring cankerworm (*Paleacrita vernata* Peck), and grape rootworm (*Fidia viticida* Walsh), can be materially reduced in numbers by thorough cultivation such as is necessary in the best orchard practice. When these insects are in the pupa stage in the soil they are very susceptible to injury, and thorough cultivation causes many of them to succumb.

THINNING OF FRUIT

In the course of thinning fruit in order to insure larger size and better quality, much can be done to reduce the numbers of certain insect pests, such as the codling moth and curculio, if the infested fruit be searched for and removed from the trees and promptly destroyed by feeding to hogs, or otherwise. Special care should also be given in thinning to remove as far as possible fruits showing blemishes of various kinds, as from injury by aphids, plant bugs, etc., thus giving the sound fruit a better chance. The unsprayed

surfaces where apples are in contact in clusters are favorite feeding grounds for many insects, and the reduction of clusters to single apples makes possible a more complete covering with spray materials, resulting in better control.

PARASITIC AND PREDACIOUS ENEMIES OF INSECTS

Most species of noxious insects are subject to attack by one or more—usually several—parasites or predatory enemies, and these natural agencies are very important factors in their control. Entomologists have given much attention to the possibility of arraying one insect against another, and in certain cases such efforts have met with pronounced success. A recent effort of this nature has been the attempt to rear an egg parasite of the codling moth on the eggs of one of the grain moths (which can be reared in large numbers the year round) and to liberate these parasites (*Trichogramma minutum* Riley) in the orchards in sufficient quantity to effect a control of the codling moth. These interesting efforts have not yet reached the point where the success of the operation on a commercial scale is assured. In the case of most orchard insect pests, however, artificial means, such as spraying, must be relied upon for their control, although the orchardist should encourage his insect and other friends as much as possible.

FIGURE 15.—Caterpillar of gipsy moth (*Porthetria dispar*) attacked by the Calosoma beetle (*Calosoma sycophanta*). Slightly greater than natural size

Owing to their diminutive size parasitic insects, especially the little 4-winged flies (fig. 14), are not usually observed by the fruit grower. His predatory insect friends, however, such as tiger beetles, ground beetles (fig. 15), ladybird beetles, etc., are more evident.

Birds are among the more important natural checks to insect life, and certain species especially frequent orchards. Woodpeckers are well known for their ability to dig out insects, and certain species are valuable aids in the destruction of the codling moth and other insects concealed beneath the bark. Other insectiverous birds frequenting orchards are warblers, creepers, titmice, flycatchers, quails, doves, etc.

The common toad is an enemy of numerous insects. Approximately 98 per cent of its food is of animal origin, and much over 60 per cent consists of injurious insects. The toad feeds during the evening and night and in 24 hours consumes an amount of insect food equal to about four times the capacity of its stomach. Numer-

ous important insects have been found in its stomach, as the plum and apple curculios, tent caterpillars, cankerworms, gipsy-moth caterpillars, and even caterpillars of the brown-tail moth (*Nygmia phaeorrhoea* Don.) with their poisonous hairs.

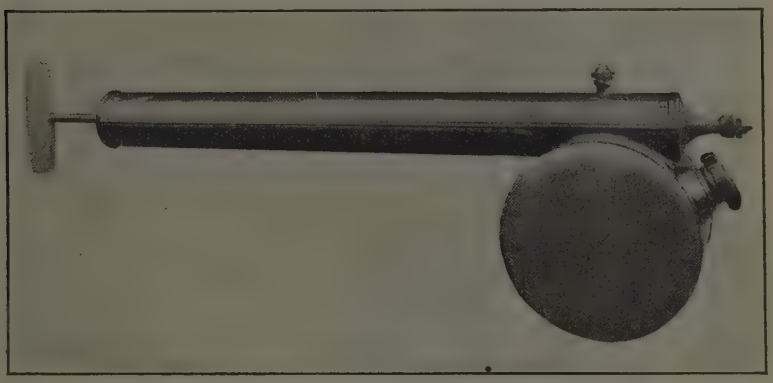

FIGURE 16.—Hand atomizer, useful for spraying a few small plants

Domestic animals sometimes may be utilized in insect control. Hogs are useful in consuming fallen, infested fruit in orchards, though the trees are frequently damaged by them. Chickens and turkeys in orchards accomplish much good in the destruction of various insects on the ground, as curculios, certain caterpillars, and the like.

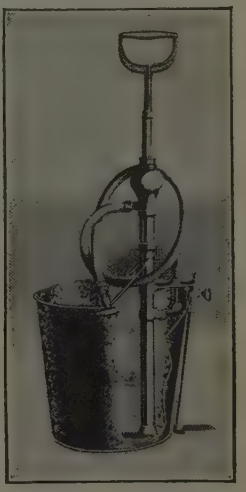

FIGURE 17.—Bucket pump, suitable for spraying a few plants and low-growing trees in home grounds. A longer lead of hose is desirable if a second person is available to do the pumping

SPRAYING OUTFITS FOR SMALL OPERATIONS

HAND ATOMIZERS

For spraying a few plants or very small trees hand atomizers may be used. These are made of brass, copper, heavy tin, or other material, and usually have a capacity of about 1 quart. (Fig. 16.)

BUCKET PUMPS

Bucket pumps (fig. 17) are fairly convenient and satisfactory for spraying small gardens and shrubs or small trees. They should be of brass or other noncorrosive metal and preferably should be equipped with an agitator. In some pumps agitation is provided by means of a small jet of the liquid which squirts from the bottom of the pump into the liquid as the pump is operated. For convenience in spraying, these pumps may be clamped to the bucket or used free in a tub or other vessel

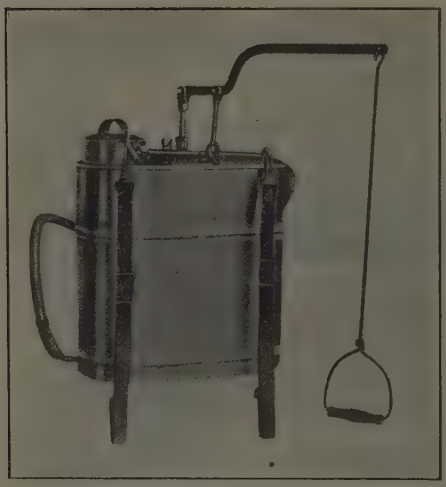

FIGURE 18.—Knapsack pump for spraying on a small scale; not extensively used now

containing the spray material. They should be supplied with a spray rod and sufficient hose to spray conveniently the plants to be treated.

KNAPSACK PUMPS

A knapsack pump (fig. 18) may be used for small spraying operations. These pumps have a capacity of about 4 gallons and are provided with an air chamber to insure pressure and a steady spray. They are carried on the back of the operator and pumped by one hand, while the other is used to hold the spray rod.

SMALL COMPRESSED-AIR PUMPS

Compressed-air pumps (fig. 19) are frequently used in small fruit gardens and are preferred to the bucket or knapsack pumps by those who do not wish to pump while applying the spray. These pumps are usually made of brass or galvanized sheet steel and have a capacity of 3 or 4 gallons. They are carried by means of a shoulder strap. In the better types agitation is provided, usually by the entrance of the air at the bottom of the tank. After the spray material is poured into the tank and the opening closed by the tight-fitting cap, the air is pumped until the liquid is under pressure. Three to four pumpings of a dozen strokes each will usually discharge all the liquid in the tank.

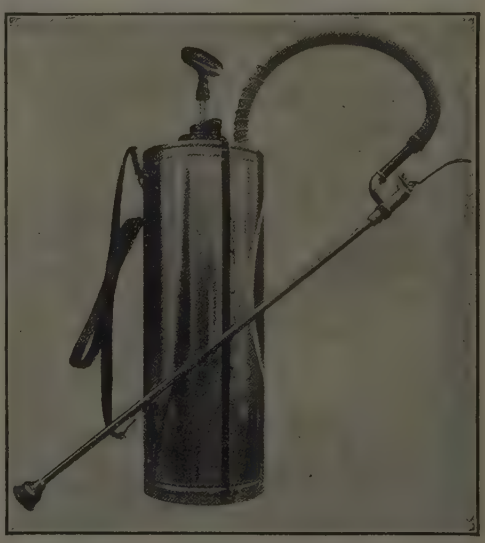

FIGURE 19.—Compressed-air sprayer for small spraying operations; no pumping is required while spraying

BARREL PUMPS

The barrel hand-pump outfit (fig. 20) has a capacity of about 50 gallons and has come into extensive use for the home orchard or fruit garden. With a good barrel pump considerable spraying may be done in a satisfactory manner. The working parts of the pump should be of bronze, brass, or other noncorrosive material, and the valves and plungers should be readily accessible and easily repaired. The pump should be provided with an efficient agitator, either of the paddle or rotary type. To insure a good pressure and uniform discharge of the spray material the pump should be provided with an adequate air chamber, to which a pressure gauge may be attached if desired. The pump may be mounted either on the head or side of the barrel, and the whole outfit placed on skids or on a wagon or truck. On hilly land it is preferable to have the barrel in a horizontal position.

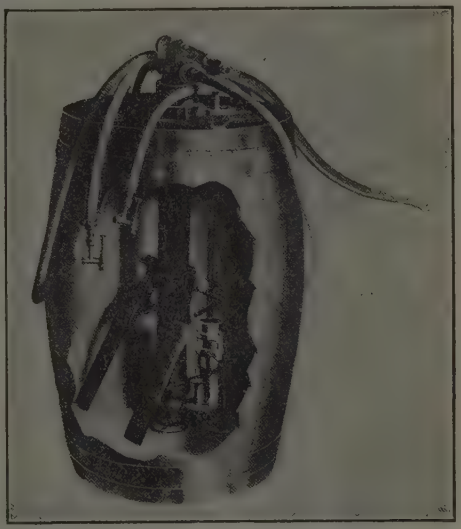

FIGURE 20.—Barrel pump, suitable for spraying the fruit garden or home orchard

DOUBLE-ACTION HAND PUMPS

The double-action hand pumps (fig. 21) are usually employed in connection with spray tanks of greater capacity than a barrel, such as the 150 or 200 gallon half-round tank used in place of the wagon bed. The pump, which may be either vertical or horizontal, is fastened to a small platform and placed on top of the tank or on a platform at the rear end of the wagon. A suction hose extends into the spray tank. A barrel or 100-gallon hogshead may be used, however, and placed at one end of the wagon bed or platform, thus leaving plenty of room for the pump and operator. When properly used these double-acting, double-cylinder pumps furnish adequate pressure for two leads of hose, and for single or double nozzles. They furnish an outfit intermediate in cost and capacity between the barrel pump and the gasoline or other power sprayer. A common defect is lack of adequate facilities for agitation, although tanks are available in which this deficiency is corrected to some extent.

SPRAYING OUTFITS FOR LARGE OPERATIONS

Spraying outfits for commercial orchards and vineyards are generally operated by gasoline engines, although traction sprayers and compressed-air outfits also are in use.

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TRACTION SPRAYERS

In the traction type of sprayer (fig. 22) the pump is geared to, or connected with, the wheels, and the pressure is generated while the spray rig is moving. These sprayers are used chiefly for low-

FIGURE 21.—Double-action hand pump for spraying home orchard or small commercial orchard

FIGURE 22.—Traction sprayer, pump being geared to the wheels. Pressure is usually inadequate with this outfit

growing crops but are sometimes used in vineyards. The difficulty of providing for sufficient pump capacity and pressure is a serious objection to the traction type of sprayer for orchard and vineyard use.

COMPRESSED-AIR SPRAYERS

Compressed-air sprayers have been used more or less in orchard spraying but are much less popular than gasoline-power outfits. Compressed-air sprayers (fig. 23) are mounted low, and owing to their small size and light weight may sometimes be used to advantage on steep hillsides where the ordinary power sprayers are impracticable. The compressed-air outfit consists of two tanks, one for the air and the other for the spray material. As the air is released into the spray tank, the spray material is forced out under a constantly decreasing pressure. The air tank is charged at a central pumping station by means of a compressed-air pump.

GASOLINE-POWER SPRAYERS

Spray pumps operated by gasoline engines are by far the most efficient type of sprayer and are made in various sizes and styles to suit almost any requirement. Special outfits have been designed for hillside spraying, vineyard spraying, shade-tree spraying, etc.

FIGURE 23.—Compressed-air sprayer, not much used except in orchards planted on steep, rough hillsides

The smallest power sprayers are nothing more than an ordinary barrel pump equipped with a small engine of 1 to 1½ horsepower. These small mechanical outfits are higher in price than the hand pump, but are usually worth the additional first cost. They may be operated at a comparatively small cost and will give a steadier spray and higher pressure than will the pumps operated by hand. With the small power outfit one lead of hose is generally used, but two leads may be employed if the pump has sufficient capacity.

Large power sprayers (fig. 24 and title-page illustration) are made with pumps of from two to four cylinders, having a capacity of from 10 to 25 or more gallons per minute under a pressure of 200 to 500 pounds. These sprayers are operated by gasoline engines of from 4 to 15 horsepower. For the 3 and 4 cylinder pumps of large capacity, auto-type 4-cylinder engines of from 10 to 15 horsepower are sometimes used.

The spraying outfits used by the majority of commercial orchardists consist of a 3 or a 4 cylinder pump with a capacity of from 10 to 20 gallons of spray material per minute and furnish a pressure of

from 225 to 350 pounds. These outfits are equipped with gasoline engines of from 4 to 6 or more horsepower and usually are provided with a 200 or 300 gallon tank and an effective agitator.

A number of reliable and efficient power sprayers are now available on the market, the various makes differing from each other in many details of construction. The fruit grower, before selecting an outfit, should consider carefully the several designs and choose an outfit that will best meet his requirements. An important factor to be considered is the readiness with which repair parts may be obtained when breakdowns occur. Delays at critical times during the spraying season are costly because of failure to get the job finished

FIGURE 24.—Gasoline-power spraying outfit with carpenter's horse type of tower and rotary-pump tank filler

in time for effective control, as well as in actual time lost. Most of the leading manufacturers of spray machinery maintain supplies of repair parts at central points in all commercial fruit regions.

STATIONARY SPRAY OUTFITS

In some sections many growers are installing stationary spray outfits. Instead of hauling a heavy spray rig with its load of liquid through the orchard, the material is pumped from a central plant through a system of piping over the entire orchard, and the spray men merely attach leads of hose to the various outlets provided at suitable intervals through the orchard. In most cases a 100-foot length of hose is used, and one man sprays while another assists in dragging the hose around. Growers who have adopted this system have found that it has many important advantages, effecting a material reduction in spraying costs, increasing the daily output of

spray material, and avoiding interference with irrigation or cultivation practices. Spraying can proceed whenever the time is right for it, irrespective of ground conditions. Since the pump and engine (or electric motor in case current is available) are permanently installed on a substantial foundation, much less trouble is experienced with the machinery, and the equipment is much less subject to wear and tear than when it is being jolted and bumped through the orchard. Orchardists considering the installation of stationary outfits should investigate the subject carefully and secure advice, if possible, from those who have such outfits in use.

DUSTING APPARATUS

The application of insecticides in the form of a dry dust has already been mentioned (pp. 9–10, 16, 25).

Apparatus of various styles and adapted to a wide range of use for applying insecticidal dusts to plants is available on the market.

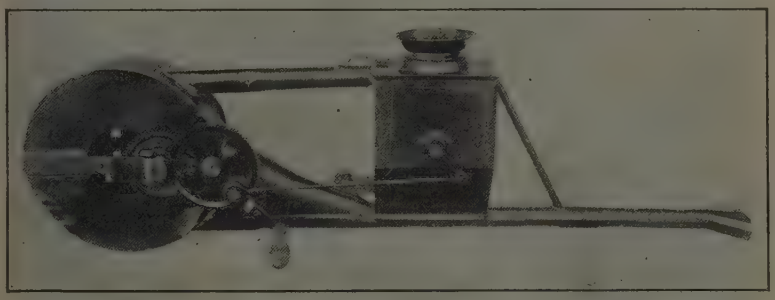

FIGURE 25.—Hand duster for applying dust mixtures in the fruit garden

HAND DUSTERS

There are several types of small dusters for treating low-growing plants, such as currants, grapes, bush fruits, and even small fruit trees. In the bellows type the air blast is generated by a bellows; in the cylinder type a piston and piston rod are utilized to make the air blast. A larger hand duster (fig. 25), suitable for rather extensive dusting operations on low-growing plants, is furnished with a fan operated by gears or by a belt from a hand crank.

The largest type of hand duster is usually mounted on a platform to be placed on a wagon or truck and is suitable for the home orchard or small commercial orchard. Machines of this type, however, are rather difficult to operate and have not come into general use.

POWER-DUSTING OUTFITS

Power dusting outfits (fig. 26) are for use in large commercial orchards. The dusters are usually operated by a 3 to 8 horsepower gasoline engine. The essential parts are the hopper, feeder, air chamber, fan, and discharge tube. The dust mixture is poured into the hopper, from which it is fed into the air chamber, where it is caught by a strong current of air generated by the rapidly revolving fan and is forcibly expelled through the flexible discharge pipe. These outfits are provided with a clutch-controlling lever and a

device for regulating the amount of material discharged. Some dusting outfits are now equipped with a self-contained mixing device. Dust materials in the proper proportions are poured into the hopper and are thoroughly mixed before being discharged.

SPRAYING ACCESSORIES

The spraying outfit is not complete or efficient unless properly equipped with useful accessories. Spraying devices that will save time or aid the fruit grower in doing more thorough work should be provided. The equipment need not necessarily be elaborate or expensive but should be sufficiently complete and modern so that the orchardist will not be handicapped when the time to spray is

FIGURE 26.—Large dusting outfit for use in commercial orchards

at hand. Spraying, to be most effective, must be done at critical periods, and delays caused by insufficient or inferior equipment may mean a heavy monetary loss.

SPRAYING TOWER

Large trees can be more effectively sprayed with the aid of a tower that will enable the spray-rod operator to reach the higher parts of the trees and to see where and how he is applying the spray material. The height and shape of the tower will depend upon the size of the trees and the distance between the rows. Square or oblong towers (cover page illustration), built over the spray tank, are most frequently used, but in orchards where the trees are close together a tower on the order of a carpenter's horse (fig. 24) will serve the purpose better. With the latter form, a platform is built at a height to permit the operator to straddle the padded horse. The towers are usually constructed of wood, steel, or iron.

SPRAY RODS

Extension rods (figs. 27 and 28) are often employed, especially with hand sprayers and with the smaller-capacity power outfits in order to reach the upper and inner parts of the trees. These generally consist of an aluminum or brass pipe contained within a bamboo pole and are made in lengths of from 6 to 12 feet. Some fruit growers use an ordinary gas pipe, but the lighter-weight spray rods are more desirable.

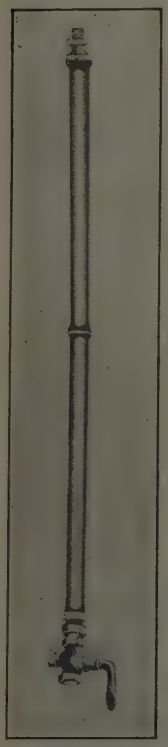

FIGURE 27.—Bamboo spray rod with cut-off

FIGURE 28.—Spray rod with double angle and disk nozzles

SPRAY NOZZLES

The whirlpool or disk type of nozzle (figs. 29 and 30) is the most popular and useful for general orchard spraying. With this type of nozzle the spray material enters an eddy chamber at a tangent, causing the liquid to whirl rapidly. The spray escapes through a small opening in the center of the disk at the top of the nozzle, producing in most cases a hollow, cone-shaped spray, although some nozzles have been designed to produce a more or less solid cone. The disks are removable and can be changed whenever desirable, as when the openings have become too large on account of wear. Disks

may be obtained with openings of various sizes, permitting the use of the size best adapted to the particular spray being applied, or to the capacity of the outfit with which it is used. The disks with large holes deliver the larger quantities of material and should not be used with pumps of small output and pressure capacity, being especially unsatisfactory for use with hand outfits. The disk nozzles are relatively small and compact and owing to the absence of any appendages do not catch in the branches of trees.

FIGURE 29.—Large eddy-chamber or whirlpool-disk type of nozzle and elbow or crook

Disk nozzles are usually made either straight (fig. 29) or angled (fig. 30). The latter throws the spray at an angle to the spray rod, is convenient for most spray work, and is especially desirable for the calyx application for the codling moth. The straight nozzles can be attached to an elbow (figs. 28 and 29) or nozzle crook in order to obtain the same results.

The original whirlpool nozzle is commonly known as the Vermorel nozzle, and as now constructed is provided with a degorger for use in cleaning the nozzle when clogged. This nozzle gives a very fine misty spray with low pressure and therefore can be used to advantage with spray pumps of small pressure capacity. The Vermorel nozzle is made singly or in clusters of 2 (fig. 31), 3, or 4 nozzles. These clusters are often a source of annoyance in orchard spraying, since they frequently catch in the twigs.

Another type of nozzle which was formerly much used is the Bordeaux nozzle. (Fig. 32.) This may be adjusted to give a relatively fine fan-shaped spray, a coarse driving spray, or even a solid stream, with all gradations between. Bordeaux nozzles do not easily clog and may be readily freed from coarse spray particles or other sediment by turning the barrel by means of the small handle on the side of the nozzle. These nozzles deliver a large quantity of material, and in order to insure a satisfactory spray the pump must have ample capacity, and a high pressure must be maintained. The Bordeaux type of nozzle has been frequently recommended for the calyx application for the codling moth to secure a coarse, driving spray. It is not so convenient to do orchard-spray work with the Bordeaux nozzle as with the whirlpool or disk types, since the handle of the former frequently catches in twigs.

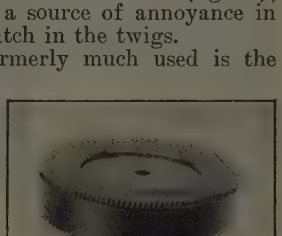

FIGURE 30.—Angled nozzle of the eddy-chamber or whirlpool-disk type

NOZZLE Y

For rapid spraying, with outfits having sufficient capacity and pressure, two nozzles per rod may be used. These can be attached to the spray rod by means of a Y. The Y's are made straight for angle nozzles or curved for straight nozzles.

SPRAY GUNS

In recent years, a number of improved devices have been invented for the application of spray materials, and certain of these are referred to as spray guns. (Figs. 33, 34, and 35.) The spray gun consists of a short metal rod, from 2 to 4 feet in length, through which the spray may be thrown a distance of 10, 15, or even more than 20 feet. These are much easier to handle than the cumbersome spray rods and in the hands of careful operators have given very good results. The nozzle itself is of the whirlpool or disk type, but is considerably larger than the ordinary disk nozzle, and has a much larger opening. Most of the guns are adjustable, so that the spray may be varied by the operator from a fine mist for application at short range to a coarse, driving spray approaching a solid stream for reaching branches at some distance. (Fig. 33, A and B.) When such a coarse stream strikes near-by branches, there is considerably more danger of injury to the foliage than with the application of a fine mist.

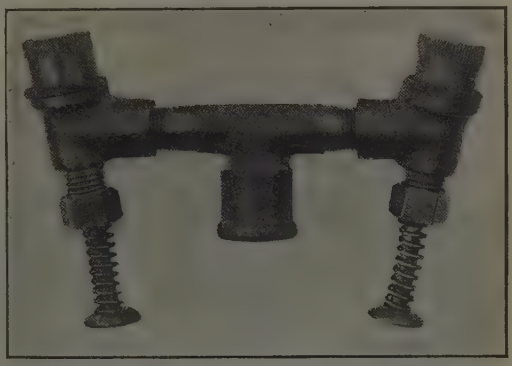

FIGURE 31.—Cluster of two Vermorel (eddy-chamber type) nozzles equipped with degorger. These nozzles often cause trouble by catching on branches

FIGURE 32.—Bordeaux nozzle, formerly much used for applying the calyx spray

Several devices have been developed which are intermediate between the short spray gun and the long rod, and which retain some of the best features of both. One of these (fig. 34) is a gun approximately 6 feet in length, with a slight bend toward the end, permitting the application of the spray from a greater number of directions than is possible with a short, straight gun. As with the short gun, this device permits the operator to vary at will the character of the spray delivered.

A second intermediate device, sometimes referred to as a "nozzle cluster gun" (fig. 35), consists of three or four large-capacity disk nozzles mounted at right angles to a short section of pipe, the whole nozzle head being mounted on a metal rod from 4 to 8 feet in length. This device delivers a driving but mistlike spray which carries a distance of 10 or 15 feet from the opening with sufficient force to turn the leaves and to some extent place spray material on both surfaces.

FIGURE 33.—A short spray gun: A, adjusted to deliver a fine mist at close range; B, the same gun adjusted to reach into the top of trees and to foliage some distance from the operator

SHUT-OFF

A shut-off between the spray hose and the base of the spray rod is a convenient device, permitting the operator to avoid waste of spray liquid by cutting off the flow in passing skips in the orchard, or between trees when they are spaced far apart. The use of a shut-off also facilitates the unclogging of nozzles when necessary. Some shut-offs are constructed with an angle, which permits the hose to hang in its natural position and thereby reduces the amount of wear on the hose at the coupling.

SPRAY HOSE

Only the best-grade high-pressure hose, usually about three-eighths to five-eighths of an inch inside diameter, should be used for spraying operations. The length of the hose for the men spraying from the ground will vary according to conditions, but should be adequate for the work to be done. In commercial orchard spraying, 50 feet of hose is desirable, and this will be long enough to permit the spray men to work around the tree without hindrance. The

length of the hose for the tower will depend upon the height of the spray tower. For use with stationary spray outfits, 100-foot leads of hose are usually employed.

HOSE COUPLINGS AND CLAMPS

It is poor economy to use lightweight hose couplings and clamps, since rough usage will soon cause them to break or blow out. Heavy couplings and clamps are obtainable, and these will give better satisfaction.

FIGURE 34.—Angle spray gun. This is a compromise between the short gun and the long spray rod. The spray may be adjusted from a very fine mist to a forceful, driving spray

TANK FILLERS

During spraying operations it is highly important to refill the spray tank quickly, since delays in filling waste the time of the team and spray men. Unless the commercial fruit grower is provided with a convenient pressure or overhead water system, a tank filler is practically indispensable. This device, which usually operates on the jet system, will promptly fill the tank from any source of water, such as a cistern or pond. Rotary pumps connected with the spray engine are employed for the same purpose and are more satisfactory where the water contains considerable sediment. Rotary pumps are frequently used in the western fruit-growing districts where the water is drawn from the irrigation ditches.

With large acreages, water should be available at numerous points in the orchard in order to avoid excessive waste of time in travel between the filling station and the portion of the orchard where the spraying is in progress. If convenient filling points can not be provided, some growers haul water or the mixed spray liquid to the spray rigs in the field in order to conserve the time of the spray crews.

PRESSURE REGULATOR

The pressure regulator is a useful attachment. By its proper adjustment a uniform spray is obtained at the pressure desired.

FIGURE 35.—Nozzle cluster gun, intermediate in type between the spray rod and spray gun. A fine mistlike spray is delivered with sufficient force to carry it to considerable distances

MISCELLANEOUS SPRAYING EQUIPMENT

The following accessories should be provided:

Scales. A good pair of scales should be used for weighing out the spray materials, unless the original packages contain the exact quantities needed. Guesswork is poor economy.

Galvanized buckets. These are useful for measuring liquid spray materials.

Strainer. Before a spray material enters the spray tank, it should first pass through a screen (fig. 36) to remove all of the coarse particles. The opening in the spray tank of a power outfit is usually provided with a removable brass screen.

Extra parts: Extra parts of the equipment most subject to wear or breakage should always be on hand. Failure to observe this precaution will frequently result in delays at critical spraying periods.

Tools: Tools specially made for the different parts of the spraying outfit are usually supplied by the manufacturer. Other standard tools, such as wrenches, screw drivers, and hammers, should also be carried in the tool box so that they may be available in case of need.

FIGURE 36.—Strainer for use in removing sediment from spray when it is being poured into the spray tank

STANDARD SPRAY MATERIALS AND THEIR COMBINATIONS FOR SUMMER SPRAYING

Orchards and vineyards are usually troubled with different classes of pests, as biting insects, sucking insects, and fungous diseases, each of which usually requires for its control a different kind of spray material. Fortunately it is

often possible to combine the necessary materials for the simultaneous control of the pests, thus avoiding separate applications.

In Figure 37 are given the standard spray materials for chewing insects, sucking insects, and fungous diseases, and the way in which they may be combined. There are three main divisions according to the principal stomach poisons in use: (1) Lead arsenate; (2) calcium arsenate; and (3) Paris green. Each of these divisions is

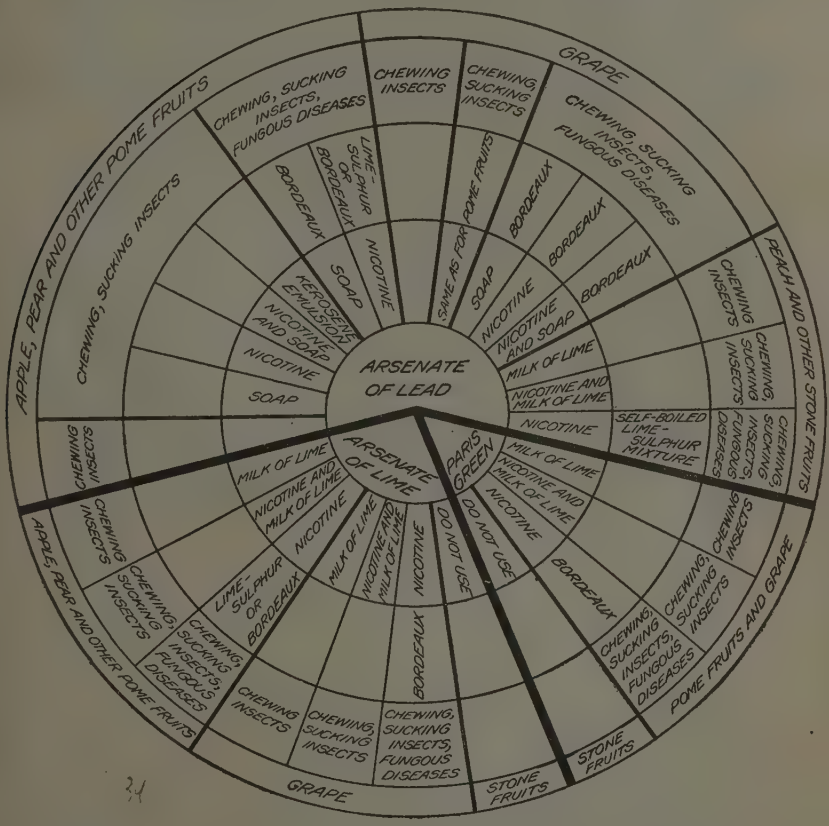

FIGURE 37.—Showing what sprays may be combined and plants which may be treated

divided in accordance with the kind of fruit: Pome fruits, grape, and stone fruits. These, in turn, are subdivided into sections: (1) Chewing insects; (2) chewing and sucking insects; and (3) chewing insects, sucking insects, and fungous diseases. These are further divided, when a choice of spray material could be given. To make use of the diagram, the first consideration is the kind of fruit to be sprayed; next, the pests to be combated; and, finally, the choice of the spray materials. In selecting the spray materials the specific recommendations given elsewhere in this bulletin should be consulted.

If pome fruits, for example, are to be treated for chewing insects, lead arsenate, calcium arsenate, or Paris green may be used; but, as will be seen in the diagram, milk of lime should be added to the latter two. If stone fruits are to be sprayed for chewing insects nothing but lead arsenate combined with milk of lime should be employed. Again, suppose apple trees are infested with chewing and sucking insects and that lead arsenate is selected for the former, it will be observed that this arsenical may be combined with soap, or nicotine, or nicotine and soap, or kerosene emulsion. If apples are to be sprayed for both chewing and sucking insects and also fungous diseases, and calcium arsenate is to be used for the chewing insects, nicotine should be added to it, and lime-sulphur or Bordeaux mixture.

SPRAY DILUTION TABLE FOR READY REFERENCE

Table 3 shows the quantity of spray material required for a number of different quantities of spray. The strength for which the materials have been computed will be found in the first column. The figures at the top of the table represent the total number of gallons of diluted spray desired, and the figures in the vertical columns give the quantity of spray material required. Thus, if 150 gallons of lead arsenate spray in the proportion of 1 pound to 50 gallons is to be used, the table shows that 3 pounds of lead arsenate is required. If 25 gallons of self-boiled lime-sulphur mixture is needed, 4 pounds of stone lime and 4 pounds of sulphur should be used. Again, if 100 gallons of lubricating-oil emulsion, 3 per cent strength, is wanted and the stock mixture contains 66⅔ per cent of oil, 4.5 gallons of the stock emulsion should be used.

TABLE 3.—*Quantities of material or stock mixtures needed for making up various quantities of spray*

SPRAY MATERIAL AND USUAL DILUTION FOR TREES IN FOLIAGE

Material and strength	Quantity of material needed for the specified number of gallons of completed spray									
	200	150	100	50	25	20	15	10	5	1
Stomach poisons:										
Lead arsenate, 1 lb. to 50 galls	4 lbs	3 lbs	2 lbs	1 lb	8 oz	6.4 oz	4.8 oz	3.2 oz	1.6 oz	0.32 oz. or 3 rounded tp.
Lead arsenate (paste), 2 lbs. to 50 galls	8 lbs	6 lbs	4 lbs	2 lbs	1 lb	12.8 oz	9.6 oz	6.4 oz	3.2 oz	0.64 oz. or 1 rounded tp.
Calcium arsenate (powder), ¾ lb. to 50 galls	3 lbs	2.25 lbs	1.5 lbs	12 oz	6 oz	4.8 oz	3.6 oz	2.4 oz	1.2 oz	0.24 oz. or 2 rounded tp.
Paris green, 6 oz. to 50 galls	1.5 lbs	1.12 lbs	12 oz	6 oz	3 oz	2.4 oz	1.8 oz	1.2 oz	0.6 oz	0.12 oz. or 0.5 rounded tp.
Contact sprays:										
Nicotine sulphate (40 per cent nicotine), 1 to 800=½ pt. to 50 galls.	1 qt	1.5 pts	1 pt	8 fl. oz	4 fl. oz	3.2 fl. oz	2.4 fl. oz	1.6 fl. oz	0.8 fl. oz	1 tp.
Nicotine sulphate (40 per cent nicotine), 1 to 1,066=⅜ pt. to 50 galls.	1.5 pts	1.12 pts	12 fl. oz	6 fl. oz	3 fl. oz	2.4 fl. oz	1.8 fl. oz	1.2 fl. oz	0.6 fl. oz	0.75 tp.
Kerosene emulsion (66⅔ per cent), 10 per cent strength.	30 galls	22.5 galls	15 galls	7.5 galls	3.75 galls	3 galls	2.25 galls	1.5 galls	3 qts	1.2 pts.
Fish-oil soap, 1 lb. to 4 galls	50 lbs	37.5 lbs	2.5 lbs	12.5 lbs	6.25 lbs	5 lbs	3.75 lbs	2.5 lbs	1.25 lbs	4 oz.
Fungicides:										
Lime-sulphur concentrate [1] [2] (33° Baumé) 1½ gals. to 50 galls.	6 galls	4.5 galls	3 galls	1.5 galls	3 qts	2.4 qts	1.8 qts	1.2 qts	0.6 qt	4 fl. oz.
Bordeaux mixture (4–4–50); stone lime, copper sulphate, each.	16 lbs	12 lbs	8 lbs	4 lbs	2 lbs	1.6 lbs	1.2 lbs	12.8 oz	6.4 oz	1.3 oz.
Self-boiled lime-sulphur mixture [1] (8–8–50); stone lime, sulphur, each.	32 lbs	24 lbs	16 lbs	8 lbs	4 lbs	3.2 lbs	2.4 lbs			

[1] Also serves as a contact spray during the summer season for newly-hatched scale insects.
[2] For dilutions of lime-sulphur differing from 32° to 33° gravity, also for dilutions of 1–50 and 1¼–50 see Table 1 (p. 13).

Abbreviations: Oz. = ounce; lbs. = pound; fl. oz. = fluid ounce; pt. = pint; qt. = quart; galls. = gallon; tp. = teaspoonful. Weights: 16 ounces = 1 pound. Measures: 7 teaspoonfuls = 1 fluid ounce; 16 fluid ounces = 1 pint; 32 fluid ounces = 1 quart; 4 quarts = 1 gallon.

TABLE 3.—*Quantities of material or stock mixtures needed for making up various quantities of spray*—Continued

SPRAY MATERIAL AND USUAL DILUTION FOR DORMANT TREES

Material and strength	Quantity of material needed for the specified number of gallons of completed spray									
	200	150	100	50	25	20	15	10	5	1
Contact sprays:										
Lime-sulphur concentrate (33° Baumé), 1 gal. to 8 galls.	25 galls.	18.75 galls.	12.5 galls.	6.25 galls.	3.13 galls.	2.5 galls.	1.87 galls.	1.25 galls.	2.5 qts.	1 pt.
Lime-sulphur concentrate (33° Baumé), 1 gal. to 9.5 galls.	21 galls.	15.75 galls.	10.5 galls.	5.25 galls.	2.63 galls.	2.1 galls.	1.57 galls.	1.05 galls.	2 qts.	0.84 pt.
Lubricating-oil emulsion, 66⅔ per cent oil content, 3 per cent strength.[3]	9 galls.	6.75 galls.	4.5 galls.	2.25 galls.	1.13 galls.	3.6 qts.	2.7 qts.	1.8 qts.	0.9 qt.	5.8 fl. oz.
Kerosene emulsion (66⅔ per cent), 25 per cent strength.	75 galls.	56.5 galls.	37.5 galls.	19 galls.	9.5 galls.	7.5 galls.	5.7 galls.	3.8 galls.	1.9 galls.	3 pts.
Kerosene emulsion (66⅔ per cent), 20 per cent strength.	60 galls.	45 galls.	30 galls.	15 galls.	7.5 galls.	6 galls.	4.5 galls.	3 galls.	1.5 galls.	2.4 pts.
Fish-oil soap, 2 lbs. to 1 gall.	400 lbs.	300 lbs.	200 lbs.	100 lbs.	50 lbs.	40 lbs.	30 lbs.	20 lbs.	10 lbs.	2 lbs.

[3] For dilutions of oil emulsion having an oil content differing from 66⅔ per cent; also for concentrations of 1, 2, and 4 per cent see Table 2 (p. 21).

Abbreviations: See preceding page.

SOME IMPORTANT INSECTS AND THEIR TREATMENT

APPLE INSECTS

INSECTS CONTROLLED BY WINTER OR DORMANT TREE SPRAYING

SAN JOSE SCALE

The San Jose scale (*Aspidiotus perniciosus* Comst.) infests the trunk, limbs, and branches of most fruit trees, apples, pears, peaches, plums, etc. The mature scale (fig. 38) is about the size of a pinhead, circular in outline, grayish in color, with a nipplelike prominence in the center. The bark of badly infested trees is ash gray and when cut into shows a reddish discoloration. Unless given effective treatment, heavily infested young trees are usually killed in two or three seasons. The vitality of older trees is quickly impaired, and eventually they are destroyed by its attack. The San Jose scale is usually controlled by one thorough spraying of the trees each year with one of the petroleum-oil sprays (p. 18) or with lime-sulphur solution (p. 11). Fish-oil soap washes may be employed (p. 23), and these are convenient where only a few trees are to be treated. Badly infested trees should be sprayed in the fall as soon as the leaves are off, and again the following spring before the buds open. Ordinarily one treatment each year, preferably in the spring, will be sufficient, although thorough work is necessary to destroy the insect so that there will be no spotting of the fruit.

FIGURE 38.—San Jose scale. Five times natural size

OYSTER-SHELL SCALE

The oyster-shell scale (*Lepidosaphes ulmi* L.) is readily recognized from the resemblance of its scale or covering to a long narrow oyster shell, as shown in Figure 39. The female scale is about one-eighth

FIGURE 39.—Oyster-shell scale. 2½ times natural size

of an inch long, brown to dark brown, though sometimes grayish in appearance. To completely kill out this species during the dormant season it is necessary to use from 6 to 8 per cent of oil. The oyster-shell scale usually multiplies rather slowly, however, and the sprays used for the San Jose scale will ordinarily keep this scale insect in check. When infesting apple, pear, etc., it may also be treated with one of the summer oils or with lime-sulphur at summer strength when the young are hatching in the spring. For any locality the hatching will usually occur during the period of one to three weeks following the blooming of the apple.

SCURFY SCALE

Although seldom very injurious to orchard trees, the scurfy scale (*Chionaspis furfura* Fitch) (fig. 40) is the subject of frequent inquiry from fruit growers and others. The dormant treatment recommended for the San Jose scale will aid much in keeping this species in check. It may also be treated with dilute scale washes as the young are hatching in the spring, as just described for the oyster-shell scale.

FIGURE 40.—Scurfy scale. Twice natural size

PEAR LEAF BLISTER MITE

The very minute creature known as the pear leaf blister mite (*Eriophyes pyri* Pgst.) (see under Pear Insects, p. 73) has become in recent years an important apple pest in some localities. It is best controlled by the dormant lime-sulphur treatments recommended for the control of the San Jose scale.

EUROPEAN RED MITE

In recent years the European red mite (*Paratetranychus pilosus* C. and F.) has done considerable damage in a number of fruit districts, the tiny mites causing a bronzing and weakening of the

foliage which in heavy infestations results in more or less defoliation. These creatures winter in the form of tiny red eggs on the twigs and smaller branches of the trees (fig. 41), where they may

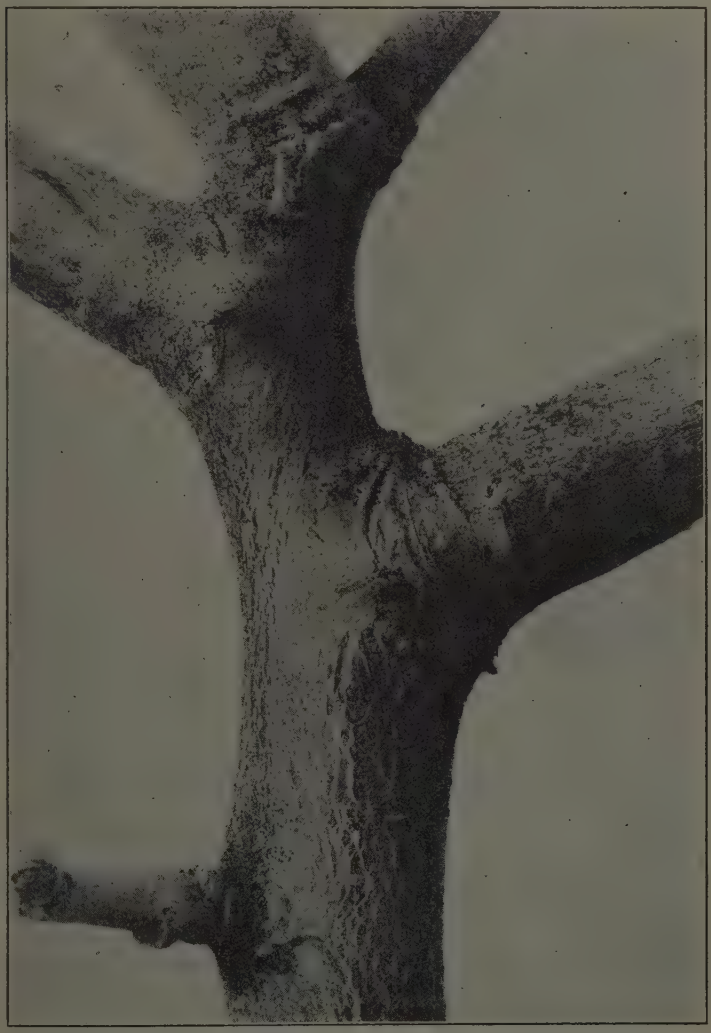

FIGURE 41.—Winter eggs of the European red mite. Magnified 2½ times

be destroyed by thorough applications of lubricating-oil emulsion at from 3 to 4 per cent strength, or by miscible oils at the dilution recommended by the manufacturer. The applications have their greatest degree of effectiveness if they are made in the spring just

as the buds are swelling rather than in the fall. Lime-sulphur is not very effective as a dormant spray for the eggs of the mite, although during the summer it has considerable value against the active stages.

APPLE APHIDS

Three kinds of aphids in particular are important pests of apple foliage, namely, the rosy apple aphid (*Anuraphis roseus* Baker), the green apple aphid (*Aphis pomi* DeG.), and the apple-grain aphid (*Rhopalosiphum prunifoliae* Fitch). These are small greenish or pink plant lice which curl the leaves. The rosy apple aphid also distorts the fruit. These insects winter on the apple trees in the egg stage, the young hatching and congregating on the buds when the latter swell and break open. (Fig. 42.) Thorough spraying at this time with nicotine sulphate (40 per cent nicotine) usually prevents serious injury later in the season. Three-fourths of a pint per 100 gallons of spray should be used. If the dormant-tree treatment for the San Jose scale with lime-sulphur solution is delayed until the buds are breaking, the scale and aphid treatment may be combined in what is often referred to as the delayed dormant application (pp. 71–72).

FIGURE 42.—Aphids clustered on expanding apple bud. Proper time to start the delayed dormant spray. This application should be completed before the leaves have pushed out one-half inch. About five times natural size.

The various oil sprays, if applied during the delayed dormant period, have more or less value in the control of the apple aphids, but are much less dependable than the lime-sulphur-nicotine combination and under some conditions, particularly in the Northwest, are likely to cause injury to the unfolding buds. The addition of nicotine to oil sprays improves their effectiveness in the control of the apple aphids.

INSECTS CONTROLLED BY SUMMER SPRAYING AND OTHER MEASURES

APPLE WORM, OR CODLING MOTH

The dirty white or pinkish caterpillar which feeds within the apple (fig. 43) is known as the apple worm, and the adult insect, into which it develops, as the codling moth (*Carpocapsa pomonella* L.). The number of broods of larvae each year ranges from one to three or four, according to latitude and altitude. The insect is usually well controlled by the timely use of arsenical sprays, the number of applications varying with different sections. A spray schedule for apple orchards is given on page 71. In controlling severe infestations, spraying must be supplemented by banding, orchard sanitation, and other auxiliary measures.

LESSER APPLE WORM

The lesser apple worm (*Laspeyresia prunivora* Walsh) infests the fruit much as does the codling moth, but the burrows are usually

not so deep, and the larva mines more under the skin in the calyx basin or on the sides of the fruit. The larva is pinkish and smaller than that of the codling moth. The treatments recommended for the codling moth will be effective in controlling the lesser apple worm.

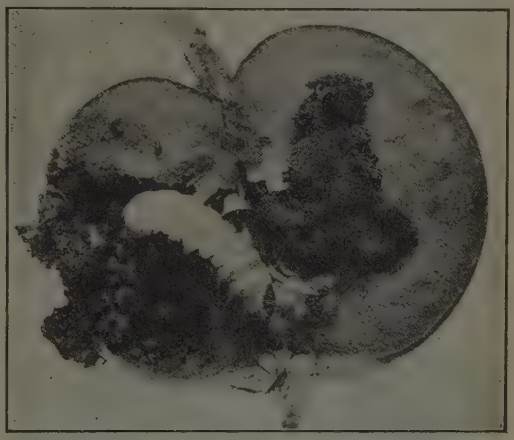

FIGURE 43.—Codling moth or apple worm and its injury to apple. Twice natural size

PLUM CURCULIO

The plum curculio (*Conotrachelus nenuphar* Herbst) is one of the causes of knotty, deformed apples. (Fig. 44.) The small snout beetles puncture the young fruit in the early spring while feeding and laying their eggs, causing much of the fruit to fall or to become misshapen as it grows, thereby destroying or lessening its market value. In addition, the beetles, while feeding in the fall, excavate small holes or cavities in the ripening fruit, which favor its decay by fungi or other causes.

FIGURE 44.—Apples deformed by plum curculio

The second and third spray applications recommended on pages 72 and 73 will aid much in reducing curculio injury to apples.

In the case of severe infestations special applications of spray in addition to those recommended in the regular schedule (p. 71) are needed during a period of about four weeks following the fall of the petals, when the curculios are most actively feeding and laying eggs. Some spray schedules recommend two applications 7 and 17 days after the calyx spray, whereas others suggest a single application 10 days after the calyx spray. In the case of orchards in sod, or more or less grown up in, or surrounded by, weeds or brush, spraying is not fully adequate, and these conditions should be corrected if possible.

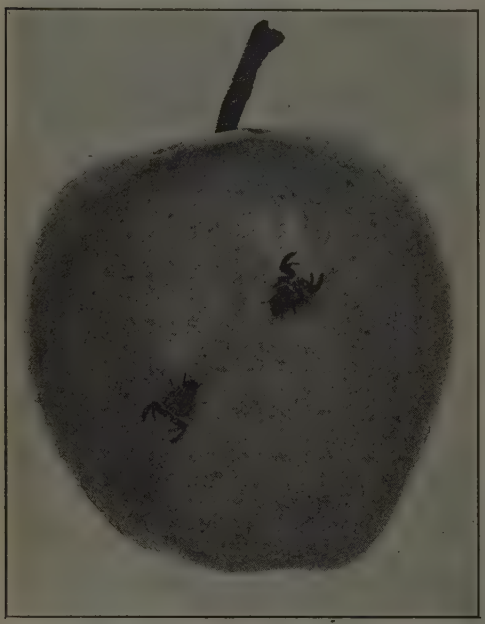

FIGURE 45.—Apple maggot. Adult flies resting on surface of apple. Slightly enlarged

APPLE MAGGOT

The apple maggot (*Rhagoletis pomonella* Walsh), also known as the railroad worm, makes discolored patches or winding burrows here and there in the flesh of the apple, and several larvae in a fruit usually will reduce the pulp to a slimy brownish mass. The insect is more or less prevalent throughout the Northeastern States. It prefers sweet and subacid varieties, especially those which ripen in late summer or early fall. The apple maggot may be controlled by keeping the foliage and fruit covered during July with a poison, such as lead arsenate, which destroys the flies (fig. 45) before egg laying begins to any extent. In attempting to control the apple maggot, it is essential to spray all infested trees. The presence of near-by sources of infestation often neutralizes any benefit which might otherwise have resulted from the application of lead arsenate. In the home orchard and elsewhere care should be taken to gather up promptly and destroy wormy, fallen fruit.

The use of lead arsenate on summer and early fall varieties of apples may result in excessive residue, necessitating its removal before the fruit is placed on the market.

APPLE RED BUGS

The sucking insects known as apple red bugs (*Lygidea mendax* Reuter and *Heterocordylus malinus* Reuter) are occasionally injurious in New York, Pennsylvania, Connecticut, and elsewhere. They puncture the little fruits early in the season, causing them to fall or become pitted and deformed. The use of nicotine sulphate (40 per cent nicotine), 1 pint to 100 gallons of spray added to one or more of the early season sprays, will give the best control. The more common of the two species usually hatches just as the apple comes into full bloom, and the calyx application comes at the right time for the control of this species. The other form hatches a little earlier, and for this one nicotine should be added to the preblossom, or pink, spray. The grower should determine the time when these bugs appear in his section, and add nicotine only to the application which coincides with their presence. A thorough driving spray is needed for the control of this pest, since the bugs are very active and dodge the spray whenever possible. (See Spraying Schedule, p. 71.)

EYE-SPOTTED BUD MOTH

The caterpillars of the eye-spotted bud moth (*Spilonota ocellana* Schiff.) attack the opening buds of the apple in the spring, and the species is particularly destructive throughout the Northern States, extending west to the Pacific coast. The dark-brown caterpillars hibernate about half grown in little cases around the buds, and as the leaves expand in the spring these are folded together by threads of silk and the caterpillars feed within them. Injured leaves often turn brown, and if the caterpillars are abundant their work is quite conspicuous. During late summer the young larvae of the new brood eat small holes in the skin of the apples, causing serious blemishes.

The usual spray schedule, which calls for the application of lead arsenate in the preblossom and calyx sprays, normally keeps the bud moth under control. In severe outbreaks, which occur locally at intervals, more drastic measures are needed. The New York experiment station at Geneva has recently reported good control from the use of strong nicotine sprays as nicotine sulphate (40 per cent nicotine) 1–400 applied during the delayed dormant period. Thorough spraying with lead arsenate during late July, special care being taken to coat the under surfaces of the leaves, is also of value in control.

CANKERWORMS

The spring cankerworm (*Paleacrita vernata* Peck) and the fall cankerworm (*Alsophila pometaria* Harris) are slender measuring worms, about 1 inch long when full grown, that feed upon the foliage of various fruit and other trees, but especially the apple and elm. (Fig. 46.) The leaves are attacked shortly after they put out in the spring and may be quickly devoured, leaving the trees brown as if swept by fire. Orchards well sprayed, as for the codling moth, suffer little. Injury to young orchards can be stopped by spraying promptly with lead arsenate upon first signs of injury. Cultivation

of orchards during early summer destroys many pupae of the spring cankerworm in the ground. Large apple and shade trees may be protected by using bands of sticky substances, cotton batting, etc., around the trunk (p. 39.) For the fall cankerworm these bands should be in place in October and for the spring form some four or five weeks before the buds are due to open.

FIGURE 46.—Spring cankerworm. About twice natural size

EASTERN TENT CATERPILLAR

In the spring the eastern tent caterpillars (*Malacosoma americana* Fab.) make their unsightly nests, or tents, in trees along the roadsides, streams, neglected orchards, etc. (Fig. 47.) The wild cherry is their favorite food, though numerous other trees are attacked when the caterpillars are abundant. They are rarely of much importance in well-sprayed orchards. The egg masses on the twigs should be searched for and destroyed when the trees are leafless, and in the spring the nests should be torn out and the caterpillars killed. Rags saturated with kerosene on the end of a pole may be used to destroy caterpillars in their nests in the higher parts of the trees.

APPLE APHIDS

Plant lice, or aphids, which were discussed on page 66, often become abundant on the apple trees during spring and summer. The delayed dormant treatment already recommended is the most effective control measure, but if the insects continue abundant when the first scab treatment is due, nicotine sulphate (40 per cent nicotine), three-fourths of a pint to 100 gallons of spray, may be added to the dilute lime-sulphur solution. It may be advisable to use the nicotine in the first codling-moth treatment also, if the aphids continue destructive, though it will serve merely to check them. The green apple aphid (*Aphis pomi* DeG.) often becomes abundant during summer, especially on young trees, but satisfactory control is difficult on account of the curled condition of the leaves.

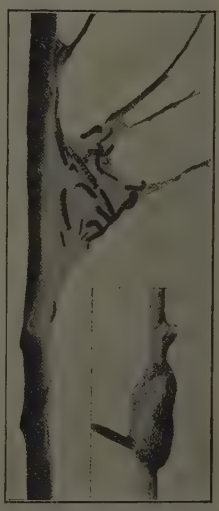

FIGURE 47.—Eastern tent caterpillars and nest; egg mass on twig on the right

ROUNDHEADED APPLE-TREE BORER

The roundheaded apple-tree borer (*Saperda candida* Fab.) infests the apple, quince, pear, and numerous wild plants, especially the serviceberry, mountain-ash, and crab. Trees are attacked at or near the base, the larvae feeding the first season under the bark and during the second and third years entering the wood. A few borers in a young tree may kill it, and older trees are always greatly injured by them. (Fig. 48.)

Fruit trees subject to attack should be wormed each year, care being taken not to injure the bark and wood more than necessary (p. 32). The beetles are laying eggs during May and June and less actively until September. They may be largely deterred from egg laying by coating the trunk of the trees, from 3 to 4 inches below the ground to about 1 foot above, with paint (p. 34). It will often be practicable to remove from the neighborhood of orchards wild host plants, such as serviceberry trees and mountain-ash.

FIGURE 48.—Roundheaded apple-tree borer and its injury to young apple tree (the bark has been removed to show the borer in its burrow). About natural size

WOOLLY APPLE APHID

The woolly apple aphid (*Eriosoma lanigerum* Hausm.) occurs on the limbs and twigs of apple trees as bluish-white colonies, or patches, but is more injurious to the roots, which become knotty and deformed, thereby stunting the trees and at times resulting in their death, especially during periods of drought. (Fig. 49.) Trees found to be suffering from the woolly aphid at the roots should be given especial care as to fertilization and cultivation, to enable them to grow in spite of the presence of the insect. Lack of growth due to unfavorable soil conditions is often attributed to this insect. Colonies of aphids on limbs and branches may be controlled with the usual contact sprays, applied liberally and under strong pressure.

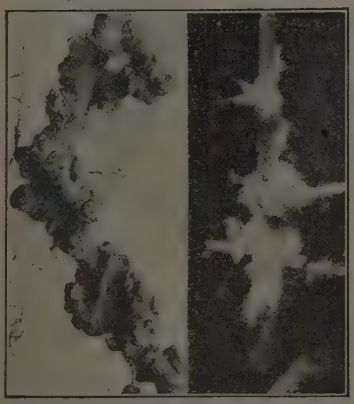

FIGURE 49.—Woolly apple aphid: Injury to root on left, and colony of aphids on twig on right

APPLE-SPRAYING SCHEDULE

DORMANT-TREE SPRAYING

During the period when the trees are dormant much stronger sprays may be used than at other times, and for this reason dormant-tree spraying is especially advisable for the treatment of scale insects, the blister mite, etc. Applications may be made in the fall after the leaves have dropped, during warm days in the winter, or in the spring before the new growth begins to appear. Where aphids are troublesome it is often practicable to delay the San Jose scale treatment until just as the buds are breaking (fig. 42), and

by adding nicotine effect a combination treatment for both the scale and aphids. For this purpose the combination lime-sulphur-nicotine mixture is more effective than the oil-nicotine combination.

FIGURE 50.—Cluster of apple blossoms in the pink stage, when first summer treatment should be made

SUMMER SPRAYING

First application.[12]—Use concentrated lime-sulphur solution (33° Baumé) in the proportion of 1¼ to 1½ gallons to 50 gallons of spray plus 1 pound of lead arsenate just before the blossoms open. (Fig. 50.) This application is for apple scab, and for chewing insects, such as the cankerworms, the bud moth, case bearers, and the tent caterpillar, and has a little value against the plum curculio. Add about one-half pint of nicotine sulphate (40 per cent nicotine) if apple red bugs are troublesome and if apple aphids are much in evidence.

Second application.—Use the same spray[13] as in the first application as soon as the blossoms have fallen. (Fig. 51.) This, known also as the calyx spray, is for the above-mentioned troubles as well as for the codling moth and leaf spot. It is the most important application for the codling moth and is also important in the control of apple scab. In spraying for the codling moth at this time the aim is to drive a quantity of the poison into the calyx end of each little apple, and to accomplish this, painstaking work is necessary. Failure to do thorough spraying at this time for the codling moth can not be remedied by subsequent applications.

FIGURE 51.—Apple blossoms from which petals have just fallen; the right time to apply the calyx spray for the codling moth

[12] In certain northern districts, delayed-dormant and prepink sprays are frequently applied earlier in the season against apple scab. See Farmers' Bulletin 1479.

[13] Many orchardists, especially in localities of codling-moth abundance, use 1½ pounds of lead arsenate to 50 gallons of spray in all summer applications.

Third application.—Use the same spray three to four weeks after the blossoms have fallen. This is the second treatment for the codling moth and leaf spot and gives further protection against apple scab and certain insects. The exact timing of this application varies in different localities. In orchards in which blotch [14] has been prevalent this application should be made not less than three weeks after the blossoms have fallen. Where this disease has been severe, Bordeaux mixture (3–4–50, p. 27) should be substituted for the lime-sulphur solution.

Fourth application.—Use Bordeaux mixture (4–4–50) and lead arsenate (1–50) 9 or 10 weeks after the petals have fallen. This is the first application for the second brood of the codling moth and for bitter rot. In orchards in which bitter rot has been a serious disease this application should be advanced about one week.

Fifth application.—Use Bordeaux mixture from two to three weeks after the fourth application. This is the second application for bitter rot; and lead arsenate should be added as a protection against late-appearing larvae of the codling moth.

Sixth application.—Use Bordeaux mixture again two or three weeks after the fifth treatment has been applied. This is the third application for bitter rot and is ordinarily sufficient to carry the fruit through, but on specially susceptible varieties in bitter-rot sections a treatment to be made two weeks later may be found necessary.

NOTE.—In severe cases of bitter rot a seventh application may be necessary, and in severe cases of blotch an extra treatment midway between the third and fourth applications is sometimes required.

In the more northern apple-growing sections the first four applications, during ordinary seasons, will be sufficient to protect the fruit from the various insects and diseases mentioned, but if the curculio is unusually destructive, one or two applications of lead arsenate, 1½ to 2 pounds in 50 gallons, should be made between the calyx spray and the third application. In severe codling moth infestations one or two additional cover sprays are applied for the first-brood worms at 10-day or 2-week intervals after the third application. In the more central States, where bitter rot and blotch are prevalent, the fifth and six applications will be necessary. In the case of summer apples only the first three applications are needed.

PEAR INSECTS

CONTROLLED BY WINTER OR DORMANT TREE SPRAYING

SAN JOSE SCALE

The San Jose scale infests pears (except Kieffer and LeConte varieties) and should be treated as described for the San Jose scale on apple (p. 63).

PEAR LEAF BLISTER MITE

The pear leaf blister mite is usually present wherever pears are grown and frequently requires treatment on pears as well as on apples. The mites winter behind the bud scales and attack the unfolding leaves and young fruit in the spring, causing reddish or greenish blisterlike spots which later in the season become brown

[14] For more specific information on control of blotch, see Farmers' Bulletin 1479.

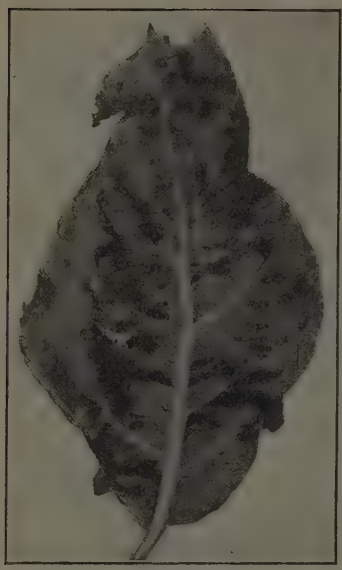

FIGURE 52.—Pear leaf blister mite injury to apple leaf

and dead. (Fig. 52.) If the attack is severe, the foliage may fall, stunting the fruit and in extreme cases causing it to shed. The lime-sulphur and oil sprays used for the San Jose scale (pp. 11 and 16) keep the blister mite in check, lime-sulphur being considered more completely effective than the oil sprays.

CONTROLLED BY SUMMER SPRAYING AND OTHER MEASURES

CODLING MOTH

The apple worm also attacks the pear, in some localities quite seriously. It should be treated as recommended for the apple, the second, third, and fourth applications of the apple spraying schedule usually being sufficient.

PEAR SLUG

The pear slug (*Eriocampoides limacina* Retz.) skeletonizes the leaves of the pear, cherry, and to some extent the plum. The slimy snail-like larvae (fig. 53) appear on the trees in May or June, according to latitude. A second brood may be in evidence about midsummer. The pest is easily controlled by arsenicals sprayed or dusted on the foliage or by the use of contact sprays.

FIGURE 53.—Pear slug and its injury. About twice natural size

PEAR PSYLLA

The pear psylla (*Psylla pyricola* Först.) is very troublesome in some regions, and careful and persistent work is required to keep it under control. The insects suck out the sap from the foliage and leaf stalks, causing the leaves to turn yellow and later brown, and many of these fall prematurely, with consequent injury to the fruit. Infested pears are usually sooty in appearance, as a result of the growth of a black fungus on the sticky excrement or honeydew voided by the insects. Adults hibernate in cracks in the bark of the trunk and limbs, under bark scales, or under trash on the ground in and near the orchard, and migrate to the trees with the very first warm days of early spring. Applications of 3 per cent lubricating-

oil emulsion at this time have given very satisfactory results. Many of the adult flies are killed, and the film of oil on the bark appears to have a great deal of residual value, reducing the number of eggs laid and killing a high percentage of the young psyllas that hatch. In Ontario, the cold-mixed Bordeaux-oil emulsion has proved the most satisfactory, and the heavier oils, having a viscosity of 150 to 200 seconds, seem to be the most effective. Nymphs of the first brood (fig. 54) congregate mostly in the axils of the young leaves and fruit and may be treated with a nicotine-soap spray, applied just after the blossoms have fallen, lead arsenate being added for the codling moth.

FIGURE 54.—Pear psylla: Immature stage. About 25 times natural size

FIGURE 55.—Pear thrips: Injury to blossoms and foliage of pear

PEAR THRIPS

The adult pear thrips (*Taeniothrips inconsequens* Uzel) come from the ground in the spring as the bud scales are spreading, and owing to their minute size are able to work their way within the scales, where they feed upon the tender tissues of leaf and flower buds. Fruits like the pear and prune, which bear the blossoms in clusters, suffer worst, and when the insects are abundant the crop may be literally destroyed in the bud. (Fig. 55.) Fruit from blossoms attacked, but which escaped destruction, is likely to be deformed and scabby and of lessened market value. The pear thrips has caused large losses on the Pacific coast and more recently has become established in the Hudson River Valley, in Maryland, and elsewhere in the East. It is controlled by spraying with nicotine and soap (p. 24), or with a mixture of nicotine and an oil spray, when the buds first begin to open, and again after falling of the blossoms. A second bud application is desirable when the insects are very abundant. Best results follow the use of a coarse spray under high pressure directed from above into the opening buds. The oil spray used, especially for the petal-fall spray, should be one which has been found safe on pear foliage.

QUINCE INSECTS

With two exceptions, the more important insects attacking the quince were discussed under apple (p. 63).

QUINCE CURCULIO

In some localities the quince curculio (*Conotrachelus crataegi* Walsh) is by far the most important insect enemy of quince. Its attack causes the fruit to become wormy and knotty, and in some sections the injuries which it causes may result in a loss of over 90 per cent of the crop. It is controlled with difficulty. Thorough spraying with a strong spray of lead arsenate when the beetles first appear and repeating the application about a week later are of value. Injury may be reduced also by capturing the beetles with curculio catchers or jarring them onto sheets placed on the ground or held under the trees (p. 36).

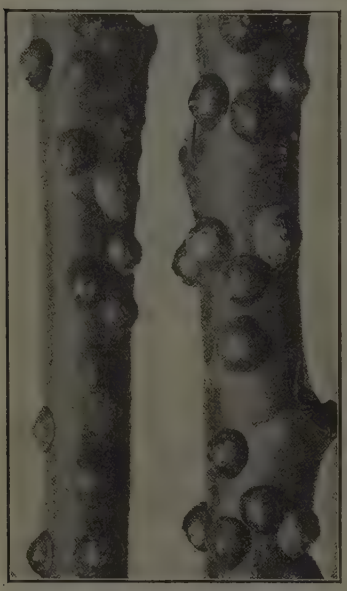

FIGURE 56.—Terrapin scale on peach twigs. About five times natural size

ORIENTAL FRUIT MOTH

The oriental fruit moth (see p. 79) is one of the most serious pests attacking the quince.

ROUNDHEADED APPLE-TREE BORER

The roundheaded apple-tree borer is often more injurious to quince than to apple. (See p. 70.)

PEACH INSECTS[15]

CONTROLLED BY WINTER OR DORMANT TREE SPRAYING

SAN JOSE SCALE

The San Jose scale requires treatment on peach, and either the winter strength lime-sulphur solution or the oil sprays may be used. (See Spraying Schedule, p. 80.)

TERRAPIN SCALE

In the middle Appalachian area the terrapin scale (*Lecanium nigrofasciatum* Perg.) (fig. 56) is sometimes very troublesome on peach and plum. The honeydew or excrement voided by the scales

[15] The insects attacking the peach in the South are discussed in greater detail in Farmers' Bulletin 1557, Insects Attacking the Peach in the South and How to Control Them. This bulletin may be obtained free from the United States Department of Agriculture.

furnishes a medium for the growth of a black mold which covers the foliage and fruit, lessening the market value of the latter. Lime-sulphur sprays are not effective against this pest, and a 4 per cent lubricating-oil emulsion or a miscible oil (p. 22) should be applied in the spring just as the buds begin to swell.

FIGURE 57.—Injury to peach shoot in the spring by the peach twig borer

PEACH TWIG BORER

The peach twig borer (*Anarsia lineatella* Zell.) tunnels into the tender shoots of the peach (fig. 57) in the spring and later attacks the fruit. Fruit injury is especially common in California and other Western States. The insect winters as a very small larva in burrows in the bark, often in the crotches of the limbs, where it may be destroyed by spraying the trees during the dormant period with a winter-strength oil spray (p. 16). Lime-sulphur solution, as used for the San Jose scale (see Spraying Schedule, p. 80) is effective if applied as the buds begin to swell in the spring.

CONTROLLED BY SUMMER SPRAYING OR OTHER MEASURES

PLUM CURCULIO

The plum curculio punctures the fruit for egg-laying and feeding purposes, causing it to fall or become knotty or distorted. (Fig. 58.) It is best controlled by spraying with lead arsenate, with the use of supplementary measures in severe infestations. Peach growers should follow the peach-spraying schedules given on pages 80 and 81, thus controlling also the peach scab and brown rot. These three are the most important causes of injury to the fruit, which are preventable by spraying.

FIGURE 58.—Injury by plum curculio to peaches

PEACH BORER

The peach borer (*Synanthedon exitiosa* Say) attacks the tree at or below the ground, eating out patches or burrows in the inner bark. (Fig. 59.) Its presence is usually indicated by the exudation from the crown of a mass of gum more or less mixed with dirt and frass. It is a very serious enemy of the peach and to a less extent of other stone fruits, and in most districts it must be controlled to prevent the destruction of the trees. The application of paradichlorobenzene to the soil about the base of each tree, as described in Farmers' Bulletin 1246, The Peach Borer: How to Prevent

or Lessen Its Ravages; the Paradichlorobenzene Treatment, gives satisfactory control for the species, but is not always safe on trees younger than 4 years. This chemical should be applied in a ring from 1 to 2 inches from the tree at the ground level, using from three-fourths to 1 ounce per tree, and covered with several inches of soil, well packed down. Paradichlorobenzene should be used during September in northern sections, and in the first half of October in the more southern sections. As a precaution against injury, the material should be removed after an exposure of from four to six weeks. If the chemical treatment is not employed, careful worming (p. 32) in the spring and fall should be practiced. A related species (*Synanthedon opalescens* Hy. Edw.) occurs on the Pacific coast.

FIGURE 59.—Full-grown peach borer and its work on young peach tree. About two-thirds natural size

LESSER PEACH BORER

The lesser peach borer (*Synanthedon pictipes* Grote and Robinson) affects principally the trunk and branches of the peach, plum, and cherry. Injury to the bark, as from the effects of freezing, barking during cultivation, careless pruning, etc., open the way for its attack. This insect may be controlled by a method recently developed by the Bureau of Entomology. This control measure consists of painting the infested area with a solution of 1 pound of paradichlorobenzene in 2 quarts of cottonseed oil. The applications should be made in fairly warm weather, with average daily temperatures of 70° F. or higher. The treatment should be restricted to the infested areas, since the paradichlorobenzene-cottonseed oil mixture is sometimes injurious to the smooth bark portions of the tree, especially the smaller branches. The conditions favoring attack by the borers—the presence of long stubs left in pruning, and injuries to the bark on the trunk and limbs—should be avoided so far as possible.

FRUIT-TREE BARK BEETLE

The fruit-tree bark beetle (*Scolytus rugulosus* Ratz.), also called the shot-hole borer, and several closely allied species, attack most fruit trees as well as related wild plants. The larvae of the bark beetles tunnel just underneath the bark, feeding on the cambium. In emerging, the adults make tiny round holes in the bark, and in stone fruits the injury is usually indicated by the exudation of gum, often copious. (Fig. 60.)

The beetles prefer sickly or diseased trees, or those in a weakened condition from any cause. Such trees when once attacked may be quickly destroyed, and the beetles on account of their abundance are thus often thought to be the real cause of the trouble. Injury is best avoided by maintaining trees in a vigorous growing condition, by cultivation, fertilization, pruning, etc. Trees recently attacked may often be saved by severe pruning and fertilization with a nitrogenous fertilizer. Thorough coating of the trunk or branches with heavy whitewash (p. 35) is desirable, as this interferes with the activities of the beetles. Trees or branches which are so heavily infested that recovery is unlikely should be removed and destroyed to prevent their serving as centers of infestation.

FIGURE 60.—Exudations of gum from peach following attack by the fruit-tree bark beetle

FIGURE 61.—Larva of the oriental fruit moth in a peach twig. The twig has been cut open to show the insect and its burrow. Four times natural size

ORIENTAL FRUIT MOTH

The oriental fruit moth (*Laspeyresia molesta* Busck) is closely related to the codling moth and to the lesser apple worm. It feeds in practically all fruits, but is especially partial to peaches and quinces. Apples may be severely infested late in the season, especially if close to blocks of peach trees. Early in the season the larvae feed in the young, growing shoots of peach (fig. 61), often passing

from one shoot to another, and injuring several before completing larval growth. As the twigs begin to harden in the summer, the larvae attack the fruit, doing serious damage, especially to late varieties.

Unfortunately, the oriental fruit moth has been found extremely difficult to control, and practical control measures are not yet available.

PEACH SPRAYING SCHEDULE

DORMANT TREE SPRAYING

Any of the usual materials for dormant spraying may be used on peach—lime-sulphur 1–7, lubricating-oil emulsions at from 2 to 4 per cent, or miscible oils as recommended by the manufacturers. Lime-sulphur has the advantage of also being effective in the control of the peach leaf curl, a disease which is sometimes prevalent in humid sections, and which is controllable only by sprays applied when the trees are dormant. In case oil emulsion is used for dormant spraying, the addition of a Bordeaux mixture (about 3–3–50) will give good commercial control of leaf curl. When used with Bordeaux mixture for scale control the oil emulsion should be used at a slightly greater strength than when used alone. If the terrapin scale (see p. 76), or the European red mite (see p. 64), is present, oil emulsion at 4 per cent strength should be used in preference to lime-sulphur.

SUMMER SPRAYING

In the eastern half of the United States most of the peach orchards should be given the combined treatment of lead arsenate and one of the mild sulphur fungicides (self-boiled lime-sulphur, dry-mix sulphur-lime, sulphur dust, etc.) for curculio, scab, and brown rot.[16] The latter disease is more especially troublesome in the South, whereas peach scab is worst in the Allegheny Mountain area and in the Northern States.

The spray program for the South differs slightly from that recommended for northern peach orchards, because of differences in the life history of the curculio. In the South during average seasons the adults reach the orchards from hibernation early enough to be poisoned by lead arsenate applied just after the petals fall, and in many seasons there is a second brood of larvae. Farther north, on the other hand, few curculios are present in the orchard before the shucks have been shed from the peaches, and no second brood of larvae develops. Two different spray schedules are therefore recommended.

Peach spray schedule for southern orchards

(Main season varieties, such as Elberta)

First application.—When 75 per cent of the petals (pink part of flower) have fallen, use 1 pound of lead arsenate, with milk of lime from 3 pounds of unslaked lime, or with 4 pounds of hydrated lime, to each 50 gallons of water.

[16] A detailed discussion of peach scab and brown rot, two important diseases of peach fruit, will be found in Farmers' Bulletin 1527, Peach Brown Rot and Scab, which may be obtained free upon request to the U. S. Department of Agriculture.

Second application.—When the calyces or "shucks" are shedding (fig. 62), or when the small peaches are exposed (this is usually about 10 days after the falling of the petals), use the same spray as recommended for the first application.

Third application.—Two weeks after the second application, or about four weeks after the petals have been shed, use self-boiled lime-sulphur, 8–8–50, or dry-mix sulphur-lime, for control of brown rot and scab. (No lead arsenate is used in this application.)

Fourth application.—Four weeks before each variety is due to ripen, spray with 1 pound of lead arsenate to each 50 gallons of 8–8–50 self-boiled lime-sulphur or dry-mix sulphur-lime.

NOTE.—Lead arsenate should not be used in all the four applications of the above schedule on account of the risk of injury to foliage and fruit.

Early peaches should be sprayed three times. Use the materials recommended for the first, second, and fourth applications, applying them at the time specified for these sprays. For added protection against brown rot in early varieties, a sulphur fungicide should be used in the second application.

FIGURE 62.—Young peaches at the stage of growth when the "shucks" are falling; this is the proper time for the first application of spray for curculio in nothern districts, and for the second application in southern peach orchards

Peach spray schedule for northern orchards

(Main season varieties, such as Elberta)

First application.—When the calyces or shucks are shedding and the small peaches are exposed (fig. 62), use 1 pound of lead arsenate and 4 pounds of hydrated lime, or the milk of lime made by slaking 3 pounds of stone lime.

Second application.—Two weeks after the first application spray with 1 pound of lead arsenate in 50 gallons of self-boiled lime-sulphur or dry-mix sulphur-lime.

Third application.—One month before each variety is due to ripen, spray with self-boiled lime-sulphur or other mild sulphur fungicide. No lead arsenate should be included in this spray, except in case of severe infestations of curculio.

NOTE.—In northern peach orchards the early varieties should receive only the first two summer applications recommended for main-season peaches.

In both northern and southern peach orchards varieties maturing later than Elberta often require one or more additional applications of sulphur fungicides to protect the fruit against brown rot through the longer growing period.

DUSTING

Dust applications are made according to much the same schedule as outlined for liquid sprays, and in the northern districts consist usually of 10 per cent of lead arsenate, 80 per cent of fine dusting sulphur, and 10 per cent of a filler, as hydrated lime, which lessens

the danger of arsenical injury. These latter proportions are varied more or less to meet local conditions. In southern peach orchards the lead arsenate content of the dusts is usually 5 per cent; more than this is likely to cause foliage injury.

FIGURE 63.—Injury to cherry foliage by the black cherry aphid

CHERRY INSECTS

CONTROLLED BY WINTER OR DORMANT TREE SPRAYING

CHERRY SCALE

The cherry scale (*Aspidiotus forbesi* Johnson) resembles closely the San Jose scale and sometimes requires treatment. Lime-sulphur solution, oil emulsions, or miscible oils are used as for the San Jose scale.

CHERRY APHID

The cherry aphid (*Myzus cerasi* Fab.) is a black, shiny aphid which curls the tender foliage of the cherry in the spring and summer, often severely checking the growth of the trees. (Fig. 63.) It winters on the trees in the egg stage, and the young aphids upon hatching congregate on the opening buds. Thorough spraying, as the buds are breaking, with a nicotine-soap spray (p. 25) or with nicotine in winter-strength lime-sulphur spray as for apple aphids (p. 66) will be effective. Summer spraying is of comparatively little value, the insects being protected from the spray by the curled-up leaves.

CONTROLLED BY SUMMER SPRAYING OR OTHER MEASURES

PLUM CURCULIO

The plum curculio seriously injures the cherry. (Fig. 64.)

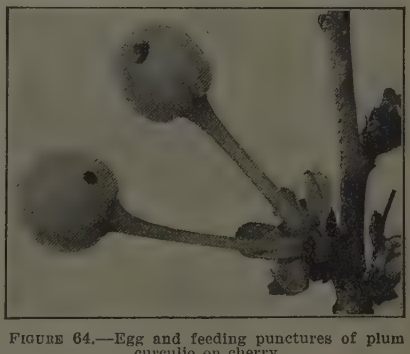

FIGURE 64.—Egg and feeding punctures of plum curculio on cherry

CHERRY FRUIT FLIES

In some parts of the Northern States cherries are sometimes infested by the maggots of two species of fruit flies (*Rhagoletis cingulata* Loew and *Rhagoletis fausta* Osten-Sacken). There is often little external evidence of infestation, though well-ripened cherries may become more or less shrunken. (Fig. 65.) Wormy

cherries thus are often gathered for market or cooking purposes, the infestation being discovered first when the maggots which have deserted the fruit are found on the bottom of the container. The adult flies feed for a number of days before egg laying and can be killed if the foliage is kept covered with a poison spray. A good spray for this purpose is 1 pound of lead arsenate in 50 gallons of water. The first application should be made in early June and occasionally repeated during the succeeding three or four weeks, depending upon the extent of removal of the arsenical by rains.

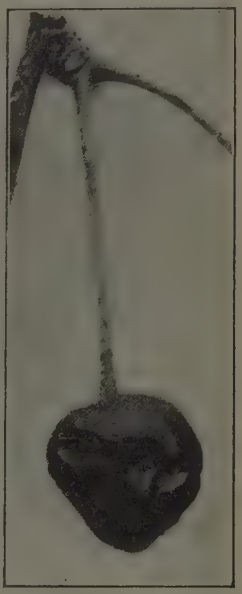

FIGURE 65.—Cherry infested with maggot of cherry fruit fly

PEAR SLUG

(See under pear, p. 74)

PEACH BORER

(See under peach, p. 77)

CHERRY SPRAYING SCHEDULE

Cherries should receive the same treatment as early varieties of peaches (fig. 66) (p. 81), except that lime-sulphur solution should be used in place of the self-boiled lime-sulphur mixture. A weaker lime-sulphur spray should be used on sweet cherries than on sour cherries, since the former are more susceptible to spray injury. Where leaf spot[17] has been severe this solution should also be used in the first treatment. For the control of leaf spot an application of the diluted lime-sulphur solution should also be made as soon as the fruit has been picked.

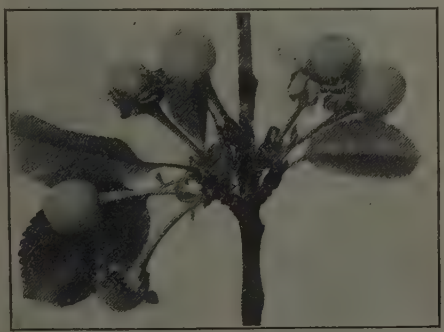

FIGURE 66.—Cherries at proper stage of growth for first spray application for curculio

PLUM INSECTS

Several peach insects, already considered, such as the San Jose scale, the terrapin and other lecanium scales, the plum curculio (fig. 67), and the peach borer, attack also the plum.

PLUM APHIDS

Three species of plant lice, the rusty plum aphid (*Hysteroneura setariae* Thomas), the hop aphid (*Phorodon humuli* Schrank), and the mealy plum aphid (*Hyalopterus arundinis* Fab.), are common on plums and often require treatment. These winter

[17] For more specific information on control of cherry leaf spot, see Farmers' Bulletin 1053.

on the trees in the egg stage. The aphids hatch in the spring about the time the buds are breaking, and later may become very numerous. (Fig. 68.) In localities where injury is usual each year, trees should be sprayed as the buds are breaking, as described for apple aphids (p. 66). Otherwise it will be sufficient to spray when the aphids are actually troublesome, using nicotine sulphate (40 per cent nicotine), three-fourths of a pint to 100 gallons of soapy water, or in one of the regular self-boiled lime-sulphur mixture and lead-arsenate sprays.

FIGURE 67.—Plums showing egg and feeding punctures of the plum curculio

PLUM-SPRAYING SCHEDULE

Japanese plums should receive the same treatment as peaches having the same ripening season. A casein-lime spreader should be added in the third application to enable the spray to stick to the smooth plum fruits.

Plums other than the Japanese varieties should receive the treatment outlined in the peach-spraying schedule, except that lime-sulphur solution diluted in the proportion of 1 gallon to 50 gallons of water is to be preferred to the self-boiled lime-sulphur mixture or dry-mix sulphur-lime as a fungicide.

GRAPE INSECTS[18]

CONTROLLED BY SUMMER SPRAYING

GRAPE BERRY MOTH

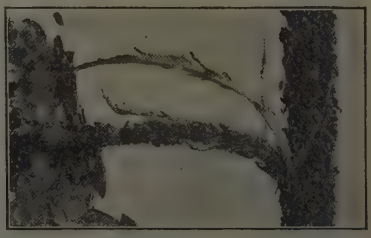

FIGURE 68.—Colony of the rusty plum aphid on plum

In late summer grape berries are often found infested by an active, greenish caterpillar about three-eighths of an inch long, the larva of the grape berry moth (*Polychrosis viteana* Clem.). It is at present destructive in northern Ohio and to a less extent in portions of the Chautauqua and Erie grape belts, as well as in other northern grape-growing districts. First-brood larvae feed on the blossom or young fruit clusters, and those of the second brood injure the green and ripening berries, often causing so much damage that the grapes must be carefully picked over by hand before being marketed. (Fig. 69.) The insect is usually well controlled

[18] The insects attacking the grape are discussed in greater detail in Farmers' Bulletin 1220, Insect and Fungous Enemies of the Grape, which may be obtained free upon request to the U. S. Department of Agriculture.

by a lead arsenate spray of 1½ pounds to 50 gallons of Bordeaux mixture, applied just after the blossoms have fallen and again two weeks later. (See Spraying Schedule, p. 89.)

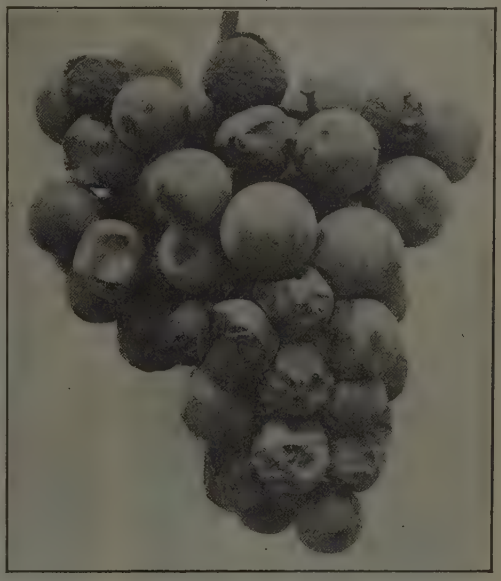

FIGURE 69.—Grapes injured by grape berry moth larvae

GRAPE ROOTWORM

The presence of the grape rootworm (*Fidia viticida* Walsh) in vineyards is shown by chainlike feeding marks of the adult beetles on the foilage. (Fig. 70.) The larvae consume the fibrous roots of the grape and eat out furrows in the larger roots, stunting the growth of the vine; and as a result the foliage becomes yellowish, and the fruit may shrivel and fall. It is a serious pest in the Erie-Chatauqua and northern Ohio grape districts and requires annual treatments to keep it reduced below injurious numbers. Since the beetles feed on the leaves during early summer and before egg laying to any extent, they may be controlled by the use of arsenical sprays applied in Bordeaux mixture, as described for the berry moth in the spraying schedule (p. 89).

FIGURE 70.—Characteristic chainlike feeding marks of adults of the grape root worm

GRAPE LEAF HOPPER

The grape leaf hopper (*Erythroneura comes* Say, and related species) is a small, agile, whitish insect with red and yellow markings often noted as abundant during summer on the lower surface of grape leaves. It feeds by sucking juices from the leaves, and its punctures cause the foliage to become blotched with white (fig. 71) and later to turn brown, many of the

leaves falling from the vines. This injury interferes with the proper ripening of the fruit and prevents normal vine growth. The insect is a pest of much importance on American varieties of grapes throughout the country generally, and especially in the Great Lakes area, and also on vinifera varieties in some sections of the West. It is controlled by the use of one-fourth pint of nicotine sulphate (40 per cent nicotine) to 50 gallons of soapy water, or Bordeaux mixture. The first application should be made when the wingless hoppers or nymphs of the first brood are present in large numbers (in the North this will be in late June or early July), as can be determined by examination. The nicotine should be used in the lead arsenate and Bordeaux mixture spray described in the spraying schedule (p. 89). Much care is necessary in spraying to hit the insects on the lower surface of the leaves.

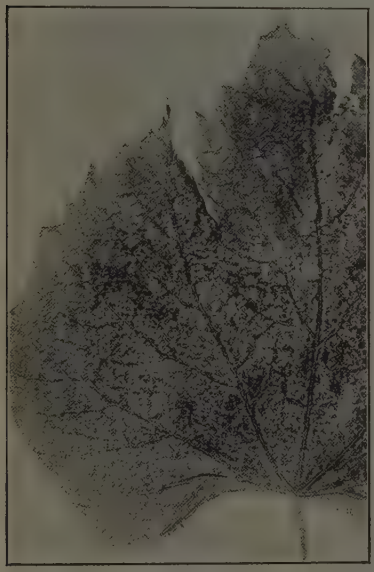

FIGURE 71.—Mottled appearance of grape leaf following attack by the grape leaf hopper

FIGURE 72.—Rose chafer, or "rose bug": Beetles attacking chestnut blossoms. Slightly enlarged

ROSE CHAFER

In some sections of the country the long-legged, yellowish-brown beetles, about one-half inch long, known as rose chafers (*Macrodactylus subspinosus* Fab.) (fig. 72) often put in appearance in large numbers about the time of blossoming of the grape, as well as of roses and many other garden flowers, stripping the plants of blossoms and foliage. They feed upon a large variety of plants, and

when very abundant do much damage in spite of treatment. Thorough spraying upon first appearance of the beetles is recommended, using 2½ pounds of lead arsenate for each 50 gallons of water, repeating the application as necessary to keep the plants coated with poison. Hand picking of beetles in the early morning may be practiced on a small scale, and bagging choice plants with mosquito netting may also be resorted to.

FIGURE 73.—Work of grape leaf folder on grape leaf

GRAPE LEAF FOLDER

Grape leaves are often rolled or folded over (fig. 73) by an active, grass-green caterpillar about three-fourths of an inch long, the so-called grape leaf folder (*Desmia fureralis* Hübn.). Within the folded leaf the larvae eat out the soft leaf substance, and when numerous may cause more or less defoliation of the vines. The larvae of the first brood appear on the vines in early summer. Well-sprayed vineyards are not seriously troubled by the leaf folder, and its injuries are usually confined to the home vineyard. Spraying the vines with lead arsenate, 1 pound in 50 gallons, when the larvae are first in evidence will keep them in check. Hand picking of infested leaves or crushing the larvae in the folded leaves is practicable where only a few vines are involved.

FIGURE 74.—Caterpillar of the 8-spotted forester on grape leaf. About twice natural size

EIGHT-SPOTTED FORESTER

The caterpillar of the moth known as the 8-spotted forester (*Alypia octomaculata* Fab.) feeds on grape foliage and is sometimes much complained of locally. The full-grown caterpillar (fig. 74) is about 1⅓ inches long with transverse black and orange stripes or bands, and there is a distinct hump near the hind end. Larvae are present on the vines from early June until about August. They may be controlled by the use of lead arsenate, as described for the grape leaf folder.

FIGURE 75.—Spraying grapes by the "trailer method," the short spray rod being held in the hand

GRAPE FLEA BEETLE

A small steely blue beetle, known as the grape flea beetle (*Haltica chalybea* Illiger), often attacks the swelling buds of the grape in the spring. The larvae of the beetles later feed upon the foliage. Where injury by this pest has been prevalent or is to be expected, vines should be sprayed as the buds are swelling with 1½ pounds of lead arsenate to 50 gallons of water or fungicide. The larvae of this insect usually are kept in check by the lead arsenate used in the first and second applications of the spray schedule (p. 89).

GRAPE SPRAYING OUTFITS

Two types of equipment are used with power outfits for spraying vineyards. The use of one type of equipment is known as the "trailer method" (fig. 75) and involves the application of the materials by means of short rods in the hands of operators who walk behind the spray outfit. A second type of equipment is known as the "boom" or "set nozzle" sprayer (fig. 76). In this case the vines are sprayed from both sides from a number of nozzles so placed that the spray converges from several directions at the same time.

FIGURE 76.—Boom attachment for vineyard sprayer. Two rows of grapes are treated at a time with spray converging from two sides

GRAPE SPRAYING SCHEDULE

First application.[19]—About a week before the blossoms are expected to open, or when the shoots have become from 12 to 18 inches long,[19] spray with Bordeaux mixture 4–3–50 (p. 27) for fungous diseases, adding from 1 to 1½ pounds of lead arsenate for the flea beetle, the rose chafer, etc.

Second application.—Just after the blossoms have fallen spray with the same materials as in the first application for the same fungous diseases and insects and for the grape berry moth, grape leaf folder, and adults of the grape root worm.

Third application.—About two weeks later use Bordeaux mixture 4–3–50 with 1 to 1½ pounds of lead arsenate, ¼ pint of nicotine sulphate (40 per cent nicotine), and 1 pound of rosin-fish-oil soap to 50 gallons of spray mixture, for fungous diseases, berry moth, eight-spotted forester, grape leaf folder, grapevine aphid (*Macrosiphum illinoiensis* Shimer), grape root worm, and grape leaf hopper. To destroy the leaf hopper direct the spray against the lower surface of the leaves. To control the berry moth, thoroughly coat the grape bunches with the spray.

Fourth application.—About 10 days later, or when the fruit is nearly grown, if black rot or mildew are still appearing, spray with neutral copper sulphate or verdigris[20] in the proportion of 1 pound to 50 gallons of water.

FIGURE 77.—Imported currant worm and its injury to currant leaf. About four times natural size

CURRANT AND GOOSEBERRY INSECTS

CONTROLLED BY WINTER OR DORMANT SPRAYING

The San Jose and certain related scales are frequently present in injurious numbers on currant and gooseberry plants, the first mentioned being especially likely to require treatment. The dormant sprays recommended for the control of this insect on fruit trees (pp. 11 and 17) are equally effective in controlling it on currant bushes.

CONTROLLED BY SUMMER SPRAYING

IMPORTED CURRANT WORM

The imported currant worm (*Pteronidea ribesii* Scop.) when full grown is about three-fourths of an inch long, uniformly green with the exception of the ends, which are yellowish. Young larvae are covered with black spots, and the head is black. (Fig. 77.) They attack both currants and gooseberries, appearing on the plants

[19] In sections where grape black rot is serious, it is essential to make an earlier application of Bordeaux mixture when the young shoots are but 2 or 3 inches long.

[20] Verdigris is basic acetate of copper.

shortly after the leaves are out in the spring, feeding at first in colonies but later scattering over the plants. Currant worms are voracious feeders and quickly strip the plants of foliage, hence treatment should be given promptly upon their discovery. Another brood of larvae appears in early summer, and in some seasons there may be a partial third brood. These insects are destroyed readily with an arsenical, sprayed or dusted over the plants. Effort should be made to destroy the first brood and prevent later injury. When the fruit is ripening, powdered hellebore should be substituted for the arsenical and should be diluted from five to ten times with flour or air-slaked lime; or used as a spray, 1 ounce to 1 gallon of water.

FIGURE 78.—Currant leaves curled by the currant aphid

CURRANT APHID

The currant aphid (*Myzus ribis* L.) curls the terminal leaves of the currant and gooseberry, especially the red currant, its presence resulting in little pits or pockets on the lower leaf surface. (Fig. 78.) A reddish color usually develops on the upper surface of injured leaves, which is visible some distance away. The aphid is easily controlled by spraying the plants as the leaf buds are opening in the spring, thus destroying the young stem mothers. The nicotine sulphate soap spray, or kerosene emulsion or fish-oil soap wash, should be used. In spraying later in the season the liquid should be directed against the insects on the lower surface of the leaves.

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